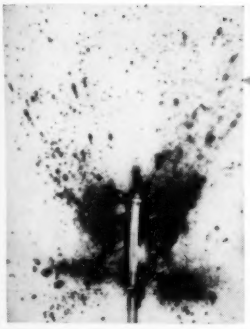
PEST CONTROL

JUNE 1959



Country's No. 1 pest may be source for insect repellent

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To control resistant roaches, know what makes them immune

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W. C. McClellan

W. C. McClellan, President

WCMc:gmn

Ft. Bragg housing unit is inspected for termite damage by Mr. G. O. Loftis (left), Pest Control Supervisor of Post Engineers, and Mr. W. C. McClellan, president, Guaranty Exterminating Co., Raleigh, N. C.

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JUNE 1959

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The Logical Choice

As more and more researchers turn their attention to resistant roaches, new explanations for this phenomenon are developed. Articles in this issue explore several theories on resistance and how your understanding of them can help you achieve better control.

Perhaps the roach's defensive spray mechanism plays a role.

Or then again, maybe resistance is rooted to biological selection — survival of the fittest. Dr. Clifford Roan writes that the resistant roaches have always been with us. At first, he says, they were strictly in the minority. But gradually they became dominant when non-resistant individuals were killed off by insecticides. If this is true, then out of populations now resistant to chlorinated hydrocarbons may emerge others resistant to organic phosphates. There is already some evidence of such a species right now.

With these and other theories on resistance, it is apparent how much more science has yet to learn about the cockroach.

The resistance battle may never end; but this won't hurt the PCO. As the problems of roach control mount and more and more skilled entomologists enter the industry, fly-by-night operators will be forced to quit because they're unable to get results. And the do-it-yourself home or property owner will find other, easier projects to tackle.

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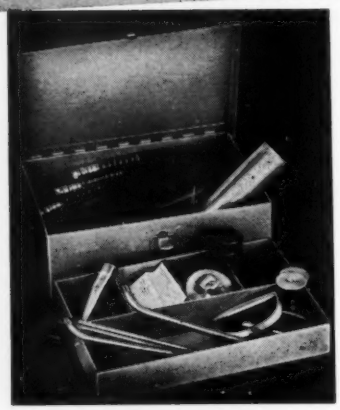

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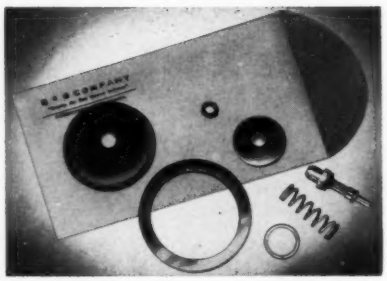

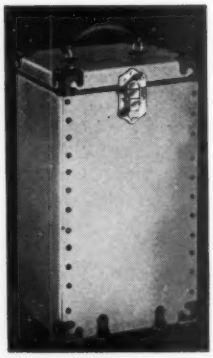

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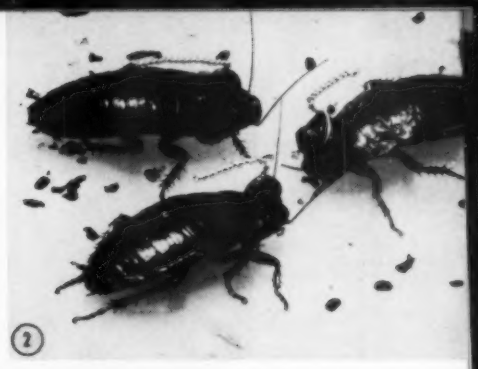
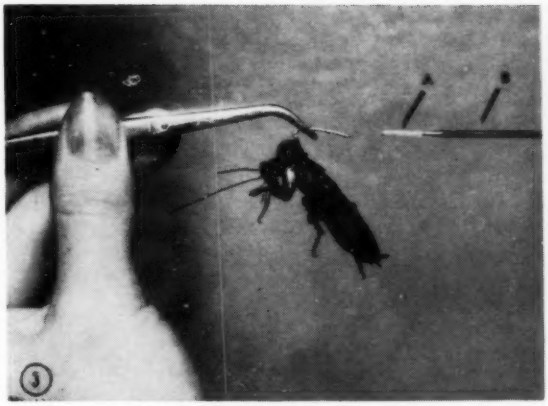
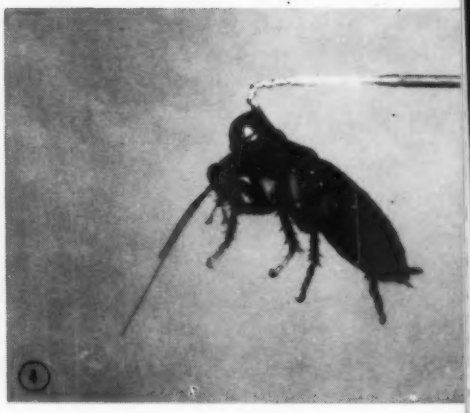


Fig. 1—Adults of the three species of roaches studied (left to right): **Diploptera punctata, Neostylopyga rhombifolia, Eurycotis floridana.** **Fig. 2**—Three **Eurycotis,** showing the metal handles used to seize them. **Fig. 3**—A **Eurycotis,** held by its handle, in the process of being attached to a brass rod (B). Note the coupling-link of plastic tubing (A). **Fig. 4**—Same roach as in fig. 3, affixed to rod.





Could this be a reason for resistance;
A new source for insect repellents?

Defense Sprays of Roaches

by T. EISENER, F. McKITTRICK, and R. PAYNE
Department of Biology, Cornell University, Ithaca, New York

ENTOMOLOGISTS have been familiar for many years with the remarkable ability possessed by certain insects and other terrestrial arthropods to eject a secretory spray, sometimes to a distance of several feet. The secretions frequently have a strong and characteristic odor, and their irritating properties have on occasion been the source of considerable annoyance and pain, especially to an unfortunate collector who inadvertently gets sprayed in his eyes.

The fact that these animals eject their spray only when prodded, handled, or otherwise disturbed, has given rise to the widespread belief that the sprays serve as means of defense against enemy predators. The crucial evidence in support of this contention, however, seemed to be missing, since actual predator attacks had only rarely been witnessed. This recently prompted us to do some simple experiments designed to demonstrate just how effective the sprays really are.

Study 3 Roach Species

We had available for study at our laboratory a large variety of spraying arthropods, including daddy-long-legs, millepedes, beetles, ants, earwigs, walking-sticks, grasshoppers, and cockroaches. We will restrict our comments here almost exclusively to the work done on three species of cockroaches (see fig. 1): *Diploptera punctata* (Eschscholtz), *Eurycotis floridana* (Walker), and *Neostylopyga rhombifolia* (Stoll).

Some work had already been done on these roaches in other laboratories, and much had been learned about the structure of the glands and the chemistry of their secretions. There remained unknown, however, some basic facts about the spray mechanisms themselves. How and in response to what kinds of disturbance is the spray ejected? What is its direction, range, and degree of dispersion? Answers to these questions seemed indispensable if one was to appreciate fully the effective potential of the sprays. A search for these answers became our first concern.

Two Problems at Onset

Two difficulties soon became apparent. First, since the sprays are usually imperceptible, except by their odor, a means had to be found for rendering them visible. This became possible by using special indicator papers impregnated with specific chemicals that discolored in the presence of the

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secretions. When a roach sprayed on a sheet of such indicator paper, the pattern of the discharge became clearly outlined.

The second difficulty stemmed from the fact that it is virtually impossible to handle the roaches without causing them to spray. Upon removal from their cages, they usually discharged repeatedly, often exhausting their secretory supply completely before one could transfer them to the indicator paper. To overcome this difficulty, we outfitted each roach with a small handle, consisting of an aluminum hook glued to the thorax just behind the head (fig. 2). Seized by this handle they could be moved about readily without ever being induced to spray.

For the experiments themselves it became necessary to prevent the roaches from moving freely over the indicator paper. To this end, each was attached to a firm brass rod. This was done simply by joining their thoracic hooks to the ends of the rods, using small coupling links of plastic tubing (figs. 3 and 4). The rods were held by universal-joint clamps, allowing the roaches to be adjusted to assume normal stances on the indicator paper. They remained linked to the rods only for as long as an experiment lasted. When it was over, the hooks were uncoupled from the rods, and the roaches returned to their cages, to be used again whenever needed.

When Will A Roach Spray?

In order to find out what specific conditions normally elicit a discharge, individual roaches, affixed to rods and placed on indicator paper, were subjected to a variety of traumatic stimuli. Appendages were lightly pinched with fine forceps, or different parts of the body were poked, tapped, or otherwise subjected to mechanical disturbance. Such stimuli invariably made them spray.

As figures 5, 6, 8, 9 clearly show, the spray patterns are by no means alike in all three species. That of *Diploptera* is much more broadly dispersed than is that of the other two. Also, *Eurycotis* and *Neostylopyga* can spray to a much greater distance than can *Diploptera*. Although our figures don't show this, we have had *Eurycotis* spray as far as three feet!

Controlled "Aim"

An unexpected additional finding was the fact that the animals can control to some extent the direction in which the spray is ejected. In *Diploptera* there are two glands, appearing on opposite sides of the abdomen, just behind the thorax. As seen in figs. 5 and 6 only that gland corresponding to the side of the body subjected to stimulation discharged at any one time. Sometimes, under special circumstances, both glands discharged synchronously. This occurred, for instance, when appendages of opposite sides were pinched simultaneously, or when a roach was persistently stimulated over its entire body surface.

Unlike *Diploptera*, *Eurycotis* and *Neostylopyga* have just a single gland, opening on the underside of the posterior half of the abdomen. The spray is invariably ejected posteriorly, but not always in exactly the same direction. By turning the abdomen to the right or to the left, they can aim with some degree of accuracy in the general direction of the stimulus (figs. 8, 9).

Certain insects other than these cockroaches can aim with much greater precision. The so called "bombardier beetles" of the genus *Brachynus* are a case in point (fig. 11). In aiming, a bombardier revolves the end of the abdomen in such a way that the tip, bearing the glandular openings, is brought to point precisely toward the stimulus. By way of

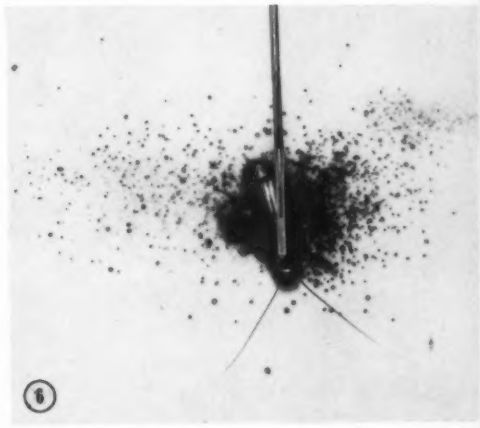
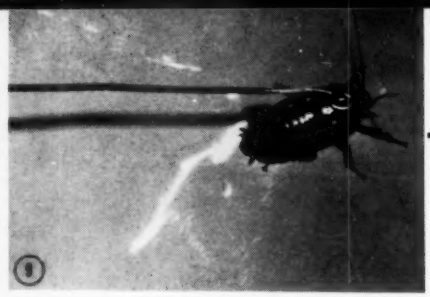


Fig. 5 — **Diploptera**: spray pattern on indicator paper following discharge of right gland in response to pinching of leg on right side. **Fig. 6** — **Diploptera:** same roach as preceding, after having sprayed a second time, but now from the left gland following pinching of leg on left side. **Fig. 7** — Two **Diploptera** exposed to attack by ants. The one on left has had its glands operated out, and is under persistent attack. The one on right was attacked, but sprayed, and repelled its assailants.



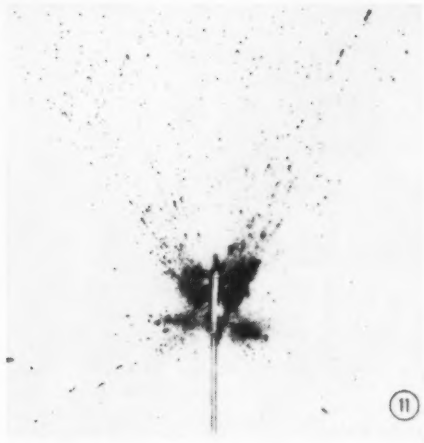


Fig. 8 — Neostylopyga: spray patterns of two consecutive discharges. The discharge on left followed pinching of left hind leg. That on right followed pinching of the corresponding leg on the right side. **Fig. 9 — Eurycotis:** spray patterns of two consecutive discharges elicited by pinching right and left hind legs, one at a time, as in **Neostylopyga** of fig. 8. **Fig. 10** — A praying mantid in the process of devouring a **Neostylopyga.** Mantids were never repelled by this roach. **Fig. 11** — A bombardier beetle after having discharged four times. The discharges were evoked by pinching in succession each of the front and hind legs. Note that every discharge is accurately aimed toward the particular appendage stimulated.

this turret-like arrangement, it can direct the spray accurately in almost every direction. Some earwigs and walking-sticks that we have been working with are capable of equally outstanding marksmanship.

The mechanisms by which the different glands operate are interesting in themselves. In some cases we do not know exactly what the mechanism is, although safe inferences can usually be made from the anatomical details of the glands. In *Diploptera* and *Eurycotis*, the glands have been admirably described in recent papers by Dr. L. M. Roth and Dr. B. Stay of the Army Quartermaster Corps., in Natick, Mass. Those of *Diploptera* appear to function somewhat like commercial atomizers. Each gland features a relatively capacious sac-like reservoir in which the secretion is stored. This reservoir leads directly to the outside, opening through a small valve-like orifice. Internally, the reservoir does not end blindly, but leads by way of a narrow connection to the internal air-tubes of the respiratory system of the insect. Ejection of the spray is presumably accomplished by forcing the air from the respiratory tubes into the reservoirs, thereby expelling and dispersing the secretion.

The single glands of *Eurycotis* and *Neostylopyga* are much less elaborate in structure. They too feature a reservoir, but in their case it is a blind sac, having no connection with the respiratory air tubes. Ejection of the secretion is apparently brought about by the contraction of special muscles that insert on the walls of the reservoir, and by the simultaneous compression of the abdomen.

Repellent Action Varies

There remained to be seen what effects, if any, the sprays had on potential enemy predators. We constructed special arenas, consisting of glass enclosures lined with indicator paper, into which individual roaches were released, together with the particular predator to be tested. Among the predators that we tried were ants, carabid beetles, praying mantids, spiders, frogs, lizards, and birds.

On the whole, the sprays proved to be tremendously effective. *Diploptera*, for example, instantly repelled most of the ants, carabids, and spiders (fig. 7). All of these predators attacked readily, each in its own characteristic way. Ants and carabids usually seized individual appendages, while spiders pounced directly upon the body itself, attempting to grasp it with their sharp chelicerae. This invariably elicited a spray ejection. As was to be expected, the discharge was always unilateral in those cases where just one side of the body had been traumatized. Hit by the spray, the assailants retreated instantly, sometimes leaving a conspicuous dark streak on the indicator paper from secretion trailing from their bodies. In most cases the roaches betrayed no signs of injury after such an attack. The predators, on the other hand, often showed conspicuous behavioral abnormalities, undoubtedly attributable to the toxicity of the secretion. The ants and beetles, for instance, had peculiar seizures, during which leg movement became completely discoordinated, and locomotion strongly impaired. Interestingly, the seizures never lasted for more than a few minutes, and were always followed by complete recovery.

Diploptera also proved quite effective in repelling frogs. Typically, a frog would leap at a roach, seize it, and then jump back instantly, spitting it out again. The roach, unhurt, would flee unmolested, leaving the frog lingering on its belly for a few

(Continued on page 44)

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UCLA tests with Desiccant Dusts for Roach Control

by DR. I. BARRY TARSHIS

Department of Entomology, University of California at Los Angeles

IT HAS LONG been known that some insects can be killed when treated with chemically inactive dusts of fine particle size. The dusts kill the insects by removing the waterproof layer of the epicuticle through a continuous adsorption of the lipid elements, or by the abrasion of this layer. Either of these actions causes abnormal water loss from the insect's body and leads to death. However, prior to the present research underway at the University of California at Los Angeles, this knowledge has never been practically applied to the control of structural or non-structural insects, except those associated with stored grains.

The Insect Cuticle

The insect cuticle, upon which sorptive dusts have such a deadly effect, is the outermost surface covering of the insect's body and makes up the exoskeleton. It consists primarily of two major parts: a relatively thick inner layer, the *procuticle*, and a thinner outer layer, the *epicuticle*. The epicuticle is of varied thickness in different insects, but is about 2 micra thick on the American cockroach. It is a complex structure made up of several layers. The *cuticulin* layer is innermost; the *polyphenol* layer comes next; the *lipid*, wax or grease, layer is third; and the cement, or *tectocuticular*, layer is on the outside. Not every insect has all four layers but, as far as is now known, all insects have at least two layers. In the cockroach only two layers have been identified in the epicuticle. In the assassin bug (*Rhodnius*) and the mealworm (*Tenebrio*) the epicuticle has been found to contain all four distinct layers. When present, the lipid layer is usually a wax layer about 0.2-3 micron thick but ranges from about 0.1 to 0.4 micron. In cockroaches this layer is a grease about 0.6 micron thick. In a few species of insects that live in a moist environment there is no evidence of a distinct lipid layer.

Kuhnelt (1928) pointed out that a surface layer of lipid material was responsible for most of an insect cuticle's impermeability to water. Ramsey (1935) and Beament (1945) demonstrated that the body of a cockroach owes its impermeability to a thin, highly mobile layer of grease that is freely exposed on the surface.

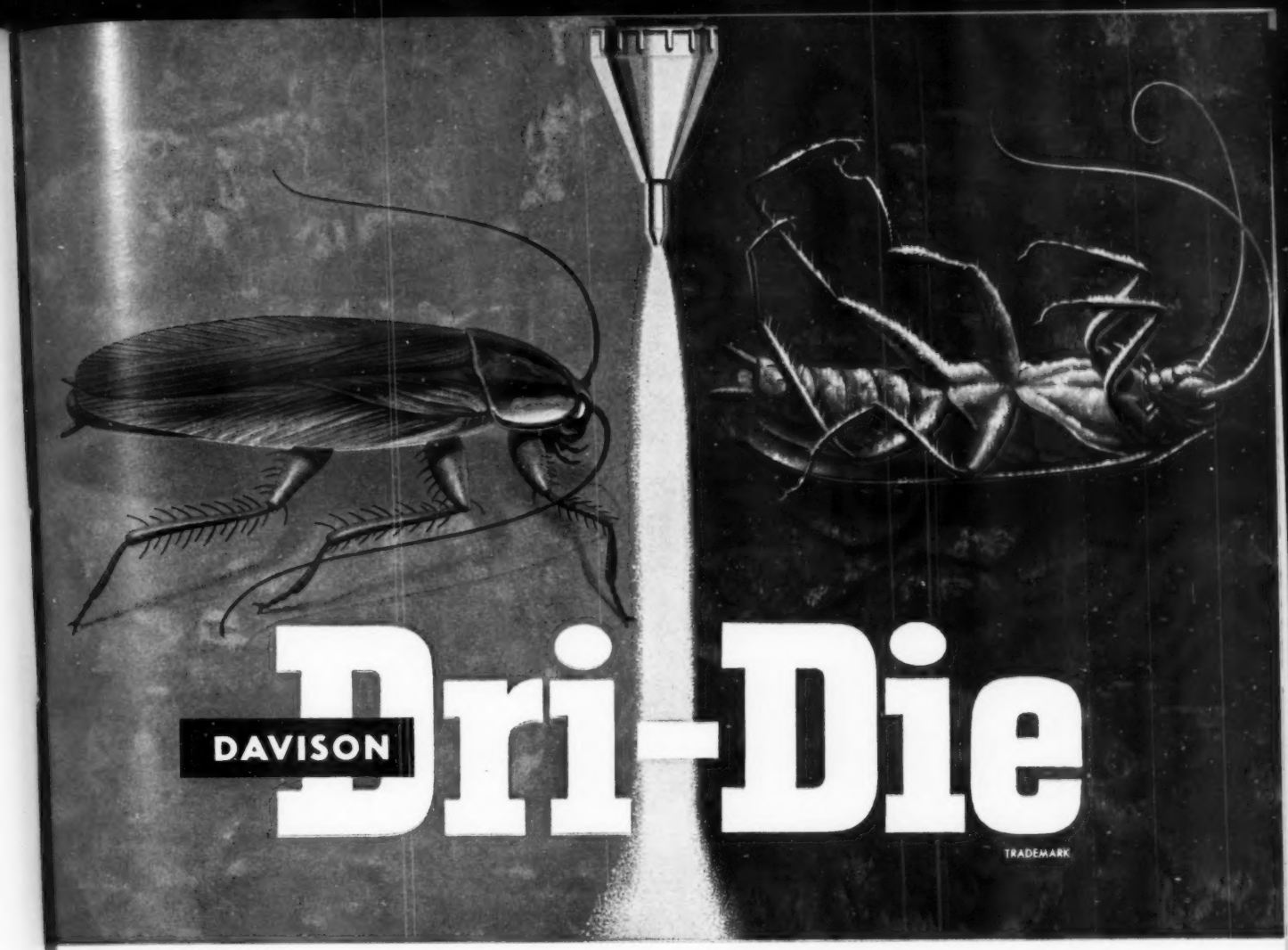
Water is a fundamental requirement for insect survival. Insects can lose large amounts of fat and protein and still live, but even a small amount of water loss may cause death. Insects cannot recover if this loss goes below the critical threshold. Germar (1936) found that this threshold in granary weevils is about 30% of the total water content of the insect body.

Previous Studies With Inert Dusts

In his studies to determine the mode of action of inert dusts in killing oriental cockroaches Hockenyos (1933) found that dusts did not kill the cockroaches by suffocation, as was previously thought, but by desiccation. The dusted cockroaches lost great amounts of body moisture, compared with the control specimens, and even the smallest particles of dust did not enter the spiracles. Pure magnesium carbonate, 1 to 10 micra in diameter, was used in these experiments.

Chiu (1939*a*) found in laboratory experiments that bentonite was the most effective compound of six inert materials he tested for killing adult bean weevils (*Acanthoscelides obtectus* (Say)). He noted that there was no difference in oxygen consumption in treated and normal weevils and concluded that dust materials do not directly affect respiration of insects. In a later paper, Chiu (1939*b*) reported on the extension of his investigations to the grain weevil (*Sitophilus oryza* (L.)) and the rice weevil (*S. granarius* (L.)). He found that crystalline silica was the most effective compound for killing these weevils. He also noted that the treated weevils died more rapidly at low relative humidities than at high humidities and that

Dr. Tarshis is an assistant professor of entomology at UCLA, also an assistant entomologist in the experiment station there.



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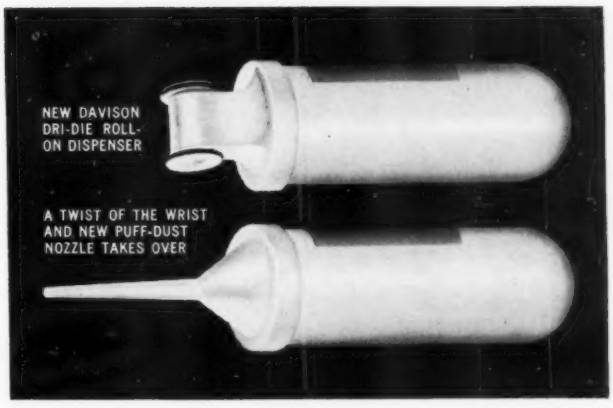

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weevils dusted with the inert materials lost weight very rapidly. He believed that the insects were killed through desiccation and mechanical irritation.

After examining 400 different dusts, Alexander *et al.* (1944) found that hard materials, such as diamond, carborundum, and quartz, were effective in killing grain weevils (*Calandria granaria* L.). Soft substances, such as talc, china clay, and gypsum, were ineffective, and compounds of intermediate hardness, such as fluorite and glass, were only moderately effective. These workers also discovered that dusts do not depend for their action on any chemical reactivity; some highly inert substances such as diamond and carborundum dusts very effectively produced desiccation in the insects. They also noted that dusts had to adhere well to the insect's body in order to be effective and that particle size plays a most important role in adhesion. The finer the particles were, the greater was their covering power. Particles of carborundum above 15 micra had no effect on the insects, but effectiveness increased as the particle size was reduced from 10 micra to about 2 micra, the latter representing the particle size with which maximum effectiveness was obtained. In comparing different dusts Alexander (Op. Cit.) found that the amount of dust adhering to the insect appeared to be relatively unimportant since some of the most effective dusts left only a very thin film, undetectable to the naked eye. Nair (1957) observed that dusts are more effective on hairy insects than smooth ones, since more dust adheres to hairy insects. He also found that the nature of the outermost layer of the epicuticle appears to influence the adherence of dust — that more clings to insects possessing soft exposed wax than those with an outer layer of hard wax or cement.

Alexander *et al.* (1944) noted that dusting increased the rate of water loss at all humidities from the moment the insects were dusted, and that the effect of the humidity on the rates of water loss of dusted and undusted insects was essentially the same. They also found that effective dusts do not themselves absorb water from the insects but merely break down the water resistance of the epicuticle. This promotes a much greater and more rapid than normal loss of water by the insect.

How Dusts Cause Water Loss

Various theories have been offered to explain how the dusts act on the epicuticle to cause abnormal amounts of water loss in insects. Zacher and Kunicke (1931) assumed a capillarity mechanism theory for the action of the dusts. They suggested that dusts increase evaporation through absorbency, like a blotter. Alexander *et al.* (1944) showed that the wax layer in granary insects was abraded when treated with dusts, resulting in a great increase in transpiration through the cuticle of the insect. Wigglesworth (1945) and Beament (1945) reported that inert dusts

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did not cause water loss in the motionless or dead insects they examined, except cockroaches. They concluded that these dusts abrade the wax off the epicuticle, thus removing the principal barrier to the transpiration of water from the insect body. They believed that, for most insects, if adsorption is a factor in desiccation it must be augmented by abrasion. Because the waterproof layer of the cockroach is a soft grease, Wigglesworth (1945) felt that this layer was largely removed by adsorption onto the dusts. By immersing dusted insects (*Rhodnius*) in a solution of ammoniacal silver hydroxide, he discovered that the phenol-containing layer of the epicuticle stained deep brown only where the protective layer of wax had been removed by the dust.

Although the dusts used by these investigators killed insects, it often took several days for this to be accomplished. These investigators emphasized the importance of abrasion, but experiments at the University of California, Los Angeles, have shown adsorption to be a much more effective mechanism in the removal of lipid material.

Although various silica and quartz compounds have been used for a number of years to help control insect infestations in stored grain, these compounds have been used only on a limited basis. Cotton and Frankenfeld (1949) reported that light applications of a silica aerogel to the surface of wheat in farm storage bins might help prevent infestation by incoming grain insects, but the use of a silica aerogel throughout the bulk of the grain to protect it against weevil damage was not recommended. Grain so treated would be classified as "treated" and would be graded as "limed", which reduces its market value. Silica dusts have also been mixed with various insecticides to make the dusts free flowing.

UCLA Studies with Sorptive Dusts and Termites

In studies to determine the toxicity of various insecticides to drywood termites (*Kalotermes minor* Hagen) after prolonged periods of time, Ebeling and

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Pence (1956) treated blocks of wood with vapor, spray, and dust formulations of DDT, chlordane, lindane, dieldrin, toxaphene, pentachlorophenol, sodium fluosilicate, and cryolite. After 17 months, Ebeling and Wagner (1959) found that the insecticide residues left on the blocks of wood treated with the dust formulations still were effective in killing termites, even though the active ingredients of the various insecticides had lost their toxicity long before. From this they concluded that the diluents used in the dusts had become the active ingredients for killing drywood termites. Wagner and Ebeling (1959) found that sorptive dust compounds were more effective than abrasive materials and that certain silica aerogels were the most effective of 162 compounds screened. The silica aerogels were found to cause death of alate termites by desiccation in 1 to 2 hours. The termites lost 30% of their body weight through water loss in this period of time.

UCLA Studies with Sorptive Dusts and Cockroaches

In September, 1957, a survey was conducted by the writer in southern California to determine which of the structural pests, other than termites, were becoming most difficult to control. The survey revealed that German (*Blattella germanica* (L.)), oriental (*Blatta orientalis* (L.)), and brown-banded (*Supella supellectilium* (Serville)) cockroaches posed the greatest control problem, due to their resistance to insecticides. Thus, this was the problem pest control operators and others were most anxious to have solved.

In March, 1958, an extensive series of experiments was begun by the writer to determine if sorptive dusts could be used for the control of cockroaches.

Initial experimental work showed that some sorptive dusts (Santocel C, Degesch 2491, Cab-O-Sil, Micro-Cel E, Multicel, Valron, Hi-Sil 233, to name a few) could kill cockroaches but were unsatisfactory for practical application because of their poor adherence properties and prolonged killing time.

During the past year, the writer has screened some 90 compounds, including synthetic silicas; synthetic calcium and aluminum silicates; tricalcium phosphates; diatomaceous earths; montmorillonite, attapulgite, bentonite and kaolinite clays; cement drifts and activated carbons. Of all these, one compound, a synthetic silica aerogel, SG 67, now designated as Dri-Die 67,[1] was found to be outstandingly effective against cockroaches in both laboratory and field tests.

During the early part of the experimental work, a compound closely related to Dri-Die 67, a synthetic silica gel called SG 77, showed promise and was used in a number of field experiments. However, further laboratory findings showed that Dri-Die 67 was much superior to SG 77 for cockroach control in that it adhered more readily to the insects' bodies, killed in a shorter period of time, and gave greater coverage with a given quantity. The greater coverage is due to the fact that SG 77 is about 2½ times heavier than Dri-Die 67. Thus, SG 77 now has been eliminated from field evaluation tests.

Silica gels and aerogels are used industrially as flatting agents for lacquer, inks and paper coatings, and as anti-blocking agents for inks and paper coatings. These compounds are formed when sulphuric acid is added to sodium silicate, producing a firm hydrogel which may be washed free of reaction salts. Upon drying, the purified hydrogel forms a granular dehydrated silica that can be reduced to very fine particle size. According to the manufacturers of Dri-Die 67, a silica aerogel has a lower density and a smaller particle size than a silica gel.

Dri-Die 67 is a highly porous, finely divided, amorphous type of silica aerogel with an average particle size of 3 micra and a density of 4.5 pounds per cubic foot. One pound of the compound will adsorb 2.55 pounds of oil. The compound is composed of 95.3% silica aerogel with 4.7% ammonium fluosilicate impregnated in less than a continuous

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monomolecular film on the internal surfaces of the compound. The addition of the ammonium fluosilicate prevents the compound from forming a hard cake when dried, and, additionally, gives the compound a strong positive charge that enables it to adhere well to the vertical and horizontal surfaces of such materials as wood, glass, masonite, Firtex, linoleum, aluminum, galvanized sheet metal, cast iron, cloth, paper, all types of painted surfaces, wallpaper, etc. It also adheres well to a cockroach's body. The monomolecular layer of ammonium fluosilicate greatly increases the insecticidal effectiveness of the compound, but does not detract from the ability of the silica aerogel particles to adsorb wax from the epicuticle. It is believed that once the wax layer has been adsorbed, the water-soluble ammonium fluosilicate comes in contact with the hydrophylic tissue of the procuticle of the insect where it dissolves and exerts its toxic effect.

The laboratory work on dusts for cockroach control was done almost entirely with the German species. However, limited studies also have been made with the American, brown-banded, and oriental species. All cockroaches used in the experimental work were reared from non-resistant stock cultures obtained from laboratories throughout the United States. Carbon dioxide anesthetization was used when it was found necessary to immobilize the cockroaches.

Laboratory Findings

In laboratory experiments, groups of 10 adult, male German cockroaches allowed to crawl through 200 milligrams of Dri-Die 67 in quart jars were down in 45 minutes and dead after 75 minutes. Groups of 10 adult, male brown-banded cockroaches treated with the same amount of Dri-Die 67 were down in 60 minutes and dead in 90 minutes. Groups of 5 adult, male oriental cockroaches allowed to crawl through 500 milligrams of Dri-Die 67 in gallon jars were down in 2½ hours and dead in 5 hours, while groups of 5 adult, male American cockroaches treated in the same manner with 500 milligrams of Dri-Die 67 were down in 4 hours and dead in 5¾ hours.

In experiments on the comparison of "continuous" and "discontinuous" exposure of adult, male German cockroaches in 200 milligrams of Dri-Die 67, it was found that the cockroaches died in the same period of time, 1¼ hours, whether left in the test compound until they died (continuous exposure) or only for 1 minute and then removed (discontinuous exposure). In the latter case, all but the fine film of dust that could not be removed by strongly shaking the cockroaches in a screen sieve for approximately 1 minute was removed. The cockroaches were then placed into clean jars and covered with a single layer of gauze to prevent their escape.

Experiments to determine the minimum amount of dust necessary to kill a German cockroach showed that a fine film of dust

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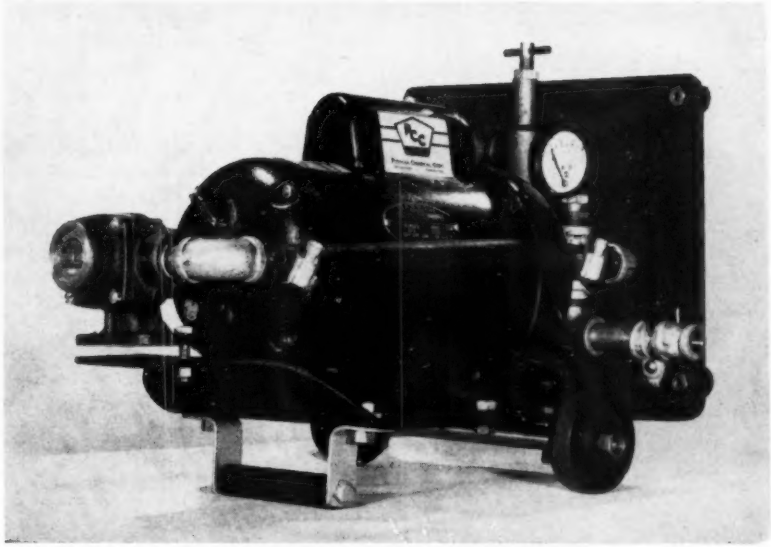

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Table 1. Quantities of Dri-Die 67 adhering to individually dusted adult, male German cockroaches and weight losses at death

	Weight of individual cockroaches before dusting (mg.)	Weight of individual cockroaches with film of dust (mg.)	Amount of dust adhering to each cockroach (mg.)	Killing time (minutes)	Weight of individual cockroaches at death (mg.)	Weight losses of individual cockroaches at death (mg.)	Per cent weight losses of individual cockroaches at death
1.	50.1	50.5	0.4	90	42.5	8.0	15.9
2.	65.0	65.5	0.5	90	57.5	8.0	12.3
3.	64.0	65.0	1.0	95	56.6	8.5	13.2
4.	62.4	63.0	0.6	85	53.7	9.3	14.9
5.	67.3	66.3	1.0	90	59.3	9.0	13.3
6.	48.0	48.3	0.3	97	41.2	7.1	14.7
7.	60.0	60.5	0.5	100	51.0	9.5	15.8
8.	73.0	74.3	1.3	90	65.0	9.3	12.7
9.	46.5	46.9	0.4	80	40.3	6.6	14.1
10.	59.6	60.0	0.4	90	52.6	7.4	12.4

Temperature = 75°F. Humidity = 50%

uniformly distributed over the cockroach's body is sufficient to bring death of the cockroach in 80 to 100 minutes. In this experiment, 10 adult, male German cockroaches were taken from a rearing jar and individually weighed. They were then placed individually into a quart jar containing 200 milligrams of Dri-Die 67 and allowed to crawl through the dust for 1 minute. After removal from the dust, each cockroach was placed into a screen sieve and shaken vigorously for 1 minute. This left only a fine film of dust uniformly distributed over its body. Each dusted cockroach was then weighed again to determine the amount of dust left adhering to its body, placed into a clean, gauze-covered jar, and observed until death occurred. At death, the cockroaches were again weighed individually to determine the amount of weight lost. The results of this experiment are shown in Table 1.

In order to ascertain how much Dri-Die 67 is necessary for 100% knockdown and kill of adult, male German cockroaches in the minimum amount of time, groups of cockroaches (10 in each group) were continuously exposed to varying quantities of material in quart jars (see Table 2). These tests showed that knockdown and killing time are definitely related to the amount of material available to the cockroach. It is for this reason that sufficient quantities of dust must be placed everywhere that cockroaches are apt to roam in a building.

It was also found during the current studies that two groups of German cockroaches — each group placed in a dusted test chamber, one with food and water and one without — died in the same amount of time and lost equal amounts of weight. In this experiment ½ the floor space area of each of two test chambers, the floor of each chamber containing 500 square inches, was covered with brown wrapping paper. Each chamber was dusted with 1 gram of Dri-Die 67. Once the dust settled, the paper was removed from both chambers. A 6-inch diameter glass dish filled with Purina Dog Chow Checkers and two 6-inch by 1½ inch diameter test tubes filled with water were then placed into one of the chambers. Thirty German males and 30 females were removed from the rearing jars and divided into two groups, 15 males and 15 females in each group. The males and females in each group were weighed separately and placed onto the untreated areas of the test chambers, although they quickly ran indiscriminately over the entire floor. The cockroaches in both chambers were dead at the end of two hours. They were removed and the two groups of males and two groups of females were weighed again. It was found that each of the two groups of males had lost the same amount of weight at death, 27%, and each of the two groups of females at death had lost 23% of their weight.

German cockroaches allowed to crawl over a wet suspension of Dri-Die 67 died in the same period of time (¾-hour) as those that were allowed to crawl over the dry material. The fact that the ammonium fluosilicate impregnated onto the Dri-Die 67 is highly soluble in water is believed to be the reason the cockroaches died equally as fast crawling over the wet material as over the dry. Other experiments have shown that cockroaches were killed 7 times as rapidly when they crawled over a wet suspension of pure ammonium fluosilicate as when they crawled over dry ammonium fluosilicate. Experiments with non-fluoride-impregnated compounds showed that wet suspensions of these materials take 24 hours to kill compared with 12½ hours for the dry material. Therefore, the faster action of the wet fluoride must compensate for the slower action of the wet silica.

It has been found that Dri-Die 67 that has been soaked and then dried again still will kill cockroaches, but the exposure period required for mortality is increased several hours. Therefore, if the dust in treated areas becomes soaked, it should either be replaced, or allowance made for the slower action of the re-dried material. This is probably partly due to the fact that the ammonium fluosilicate is dissolved by water, and partly that the re-

Table 2. Knockdown and killing time for adult, male German cockroaches continuously exposed to various quantities of Dri-Die 67.

Milligrams of Dri-Die 67 used per quart jar	Hours required for 100% Knockdown	Kill
5	3½	4
10	2½	3
15	2	2½
20	2	2½
25	2	2½
35	¾	1¼
40	¾	1¼
45	¾	1¼
50	¾	1¼
65	¾	1¼
125	¾	1¼
200	¾	1
250	¾	1
375	½	1
500	½	1

10 cockroaches per quart jar per test.
Temperature = 70°F. Humidity = 44%

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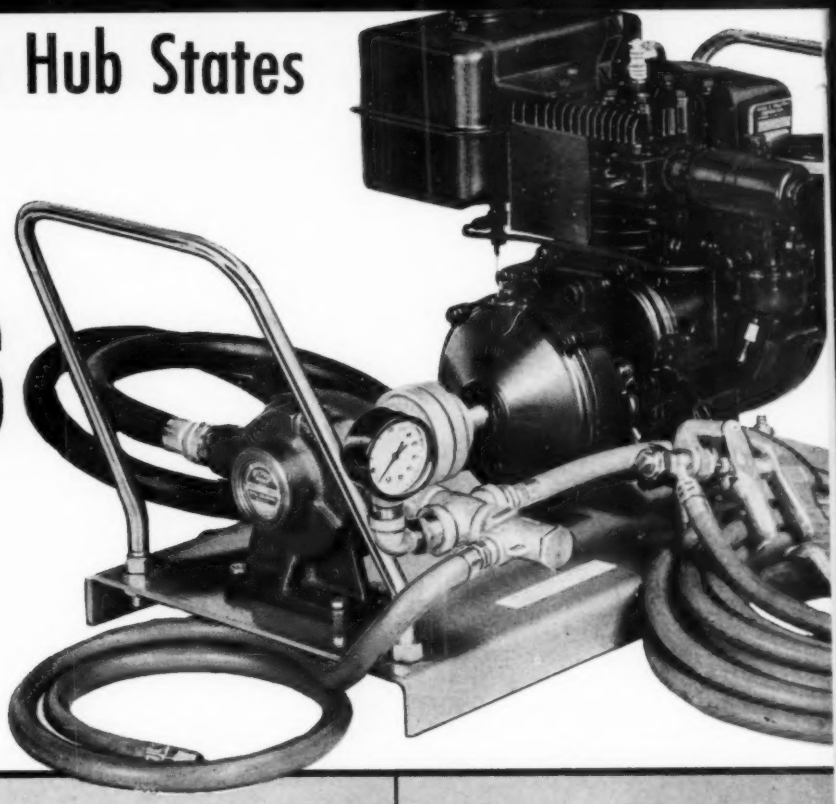

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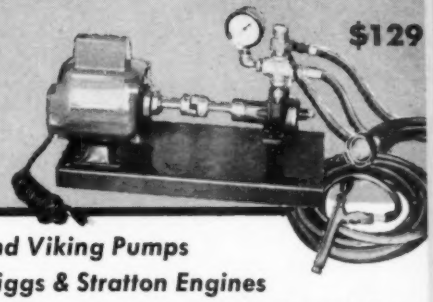

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dried material, being somewhat caked, may be less readily picked up by the cockroaches.

Exposure of dusted German cockroaches to four different humidities, 25, 50, 75 and 100%, resulted at the end of two hours in the death of all the cockroaches. Ten adult, male German cockroaches were placed into each of four jars, each containing 200 milligrams of Dri-Die 67. The roaches were allowed to crawl through the test material for 1 minute. Each group of cockroaches then was removed from the material and shaken vigorously for 1 minute in a screen sieve, which left only a fine film of dust on their bodies. Next, they were placed into clean jars, the tops covered with gauze. The jars were placed into humidity chambers and the cockroaches checked until all were dead. The same experimental procedures were duplicated in tests with German cockroaches and two non-fluoride-impregnated compounds, one a synthetic silica and the other a tricalcium phosphate compound of fine particle size. Cockroaches dusted with these two compounds died at the end of 5 hours when held at 25, 50 and 75% humidities; however, those held at 100% humidity were not dead until 10 hours after exposure.

Comparative studies between Dri-Die 67 and powdered technical grades of 20 other insecticides showed that Dri-Die 67 kills German cockroaches in a shorter period of time than any of the other tested insecticides. In this experiment the powdered technical grades of the insecticides were used rather than the formulated compounds since the writer has found that a number of the diluents used in insecticides are in themselves very effective for killing cockroaches. If the formulated compounds were used, it would have been very difficult to determine whether the diluents or toxicants in these formulations killed the cockroaches. The results of this experiment are given in Table 3.

Experiments to determine, by weight loss, the amount of water lost by German, American, brown-banded, and oriental cockroaches dusted with Dri-Die 67 showed that cockroaches so treated lost abnormal quantities of water in comparatively short periods of time (Table 4). In these experiments the German and brown-banded cockroaches (10 of each sex for each species) were removed from rearing jars, weighed and placed into jars, each of which contained 200 milligrams of the test compound. The cockroaches were allowed to crawl through the material for 1 minute. They were then removed and shaken vigorously in screen sieves for 1 minute to remove all possible dust on their bodies. Finally, they were placed into clean jars covered with gauze. At death the cockroaches again were weighed to determine the amount of weight lost. The oriental and American cockroaches (five of each sex for each species) were handled identically, except that they were weighed individually and allowed to crawl through 500 milligrams of Dri-Die 67 in gallon jars. Even though the ammonium fluosilicate impregnated on Dri-Die 67 hastens death once the lipid layer of the cockroach has been adsorbed by the silica aerogel, the great amount of water loss in dust-treated cockroaches is felt to be the primary factor in bringing about the death of the insect.

Table 3. Comparative studies on Dri-Die 67 and powdered technical grade insecticides for killing adult, male German roaches.

Compounds tested		Hours required for 100% Knockdown	Kill
Dri-Die 67	100%	¼	¾
Lindane	12%	¼	1¾
Lindane	1%	¼	2½
BHC	12%	¼	2¾
Dilan	25%	¼	2¾
Parathion	25%	½	4¼
Sodium Fluoride	98%	¾	1¼
Diazinon	25%	¾	2¾
Methoxychlor	50%	1	2¾
Dieldrin	50%	1	2¾
Heptachlor	25%	1	2¾
Korlan	25%	1¾	2½
Aldrin	25%	2½	4
Dipterex	100%	2½	7½
TDE	50%	2¾	4
Aldrin	96.8%	2¾	8
DDD	50%	4	5½
Chlordane	40%	4	9
Lindane	100%	10	None dead at end of 10 hours
DDT	100%	13	Only 1 dead at end of 52 hours
Rotenone	100%	None down or dead at end 52 hours	

5 males used per test compound in each quart jar. 500 milligrams of each test compound used.

Temperature = 78°F. Humidity = 42%

Other experiments were conducted to determine the effectiveness of Dri-Die 67 against German cockroaches after the chemical had been exposed to the atmosphere for a long period of time. It was found that the cockroaches treated with material that had been left in open jars on a laboratory shelf for 258 days after being previously used, were killed in 1¾ hours. This was ½ hour longer than it usually takes to kill these cockroaches with clean, fresh material.

Field Tests with Dri-Die 67

In April, 1958, the first field test with silica compounds was made in a Hollywood, Calif., home that was infested with oriental cockroaches. The owner of the home had requested help after having applied a number of spray and dust insecticides himself, which failed to control the infestation. Since laboratory findings had begun to indicate that some of the synthetic silicas being tested might be of practical value, the treatment of this home was

Table 4. Killing time and weight losses of adult, male and female, German, American, brown-banded and oriental cockroaches treated with Dri-Die 67.

Cockroaches Treated	Time required for 100% kill		Weight losses at death		Weight losses after completely desiccated	
	Males (minutes)	Females	Males (%)	Females	Males (%)	Females
German	45	95	20	20	66	61
Brown-banded	160	190	35	25	64	66
Oriental	180	240	19	17	64	66
American	270	450	21	28	70	67

Temperature = 75-80°F. Humidity = 50-58%

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Table 5. Field experiments on the use of SG 77 and Dri-Die 67 for the control of oriental Cockroaches.

Location	Infestation	Material and quantity used (pounds)	Areas dusted	Date dust applied	Results (No live roaches seen after date given)
One-story home, Hollywood	Moderate	SG 77—1½	Kitchen, service porch	4-18-58	4-28-58
One-story home, Brentwood	Moderate	SG 77—1½	Garage, service porch	4-28-58	5-6-58
One-story home, Mar Vista	Moderate	SG 77—1½	Kitchen, service porch	4-29-58	5-1-58
Duplex (upper), Hollywood	Moderate	SG 77—1½	Kitchen, service porch	5-16-58	5-16-58
Duplex (lower), Hollywood	Moderate	SG 77—1½	Kitchen, service porch	5-16-58	5-16-58
One-story home, Mar Vista	Moderate	SG 77—1½	Kitchen, service porch	5-16-58	5-26-58
One-story home, Mar Vista	Moderate	Dri-Die 67— ¾	Kitchen, service porch, bathroom	5-29-58	5-29-58
Two-story apartment	Moderate	SG 77—2	Garage, furnace room	6-9-58	6-9-58
One-story home, Mar Vista	Moderate	SG 77—1½	Kitchen, service porch, bathroom	6-9-58	7-16-58
One-story home, Culver City	Moderate	Dri-Die 67— ¾	Kitchen, service porch	7-2-58	7-23-58
One-story home, Mar Vista	Moderate	Dri-Die 67—1	Kitchen, service porch, garage	7-18-58	8-7-58
Two-story apartment (upper) Pacific Palisades	Moderate	Dri-Die 67— ¾	Kitchen, service porch, bathroom	8-4-58	8-4-58
Fire Station, Glendale	Heavy	Dri-Die 67—1½	Kitchen, recreation room, laundry room, shop	8-13-58	8-13-58
Two-story apt., Long Beach	Light	Dri-Die 67— ¾	Kitchen, bedrooms, bathroom, stairwell, closets	11-17-58	11-24-58
Two-story apt., Long Beach	Moderate	Dri-Die 67— ¾	Kitchen, bedrooms, bathroom, stairwell, closets	11-18-58	11-24-58

undertaken with SG 77. It was applied in a number of key areas in the kitchen and on the service porch of the home. Three days following application of the dust, the home was inspected and a number of dead, dust-covered orientals were found. The occupants reported that no live cockroaches had been seen since the dusting. They also found a considerable number of the dead, dust-covered insects. Several other inspections of this home by the writer revealed only dead, dusted cockroaches. After approximately 11 months the occupants informed the writer that their home was still completely free of cockroaches.

Preliminary studies with Dri-Die 67 in a large, heavily infested housing project in this area have been so successful that an extensive full-scale control program has been inaugurated and is now in progress. More details will be reported when this test is concluded.

Since the first application of SG 77, more than 70 other establishments in southern California, including private homes, apartments, libraries, restaurants, drug stores, a sanitarium, and a fire station have been dusted. This has been mostly with Dri-Die 67 for reasons explained previously. Dri-Die 67 is now used exclusively in all field tests. Details of 40 of these field experiments are given in Tables 5, 6, and 7.

In all homes dusted with Dri-Die 67, occupants not only reported the complete elimination of cockroaches, but also of ants and silverfish, two other major pests in this area.

Reports from a number of PCOs, sanitarians, and other researchers around the country who have used and are now using Dri-Die 67 for cockroach control report good to excellent control.

Although the writer has not made any field tests with Dri-Die 67 for the control of American

Table 6. Field experiments on the use of Dri-Die 67 for the control of Brown-Banded Cockroaches

Location	Infestation	Quantity used (pounds)	Areas dusted	Date dust applied	Results (No live roaches seen after date given)
One-story home, Anaheim	Moderate	¾	Kitchen, service porch	5-27-58	6-1-58
One-story home, Mar Vista	Moderate	¾	Kitchen, service porch, bathroom	7-22-58	7-29-58
One-story home, Compton	Moderate	¾	Kitchen, service porch	9-8-58	9-15-58
Two-story apt. (lower) Pasadena	Moderate	¾	Kitchen, bathrm., bedrm.	9-22-58	9-22-58
Two-story apt. (upper) Pasadena	Moderate	¾	Kitchen, bathrm., bedrm.	9-22-58	9-22-58
Two-story apt. (upper) Pasadena	Moderate	¾	Kitchen, bedrm., bathrm.	9-22-58	9-22-58
Two-story apt., Long Beach	Light	¾	Kitchen, bedrms. bathrm. stairwell	11-17-58	11-24-58
Two-story apt., Long Beach	Moderate	¾	Kitchen, bedrms. bathrm. stairwell	11-18-58	11-24-58

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cockroaches, reports on the use of the compound by others have indicated that these insects can be controlled with this compound just as successfully as the other species. Laboratory experiments made by the writer with Dri-Die 67 on American cockroaches show that they can be killed in approximately the same period of time as the oriental species.

Toxicity of Dri-Die 67

Pure silica aerogel is nontoxic to humans and warm-blooded animals. For many years it has been used by ethical pharmaceutical companies in preparations for internal use and it has been used for more than 20 years in a personal dusting powder. Because this compound is amorphous rather than crystalline in nature it will not cause silicosis.

As to the toxicity of the compound resulting from the impregnation with ammonium fluosilicate, the writer has been informed by the manufacturer that prior to its present use as an insecticide, the compound has been used industrially for up to 10 years with no toxic effect experienced by plant personnel or users. During the six months that the product has been marketed experimentally to the pest control industry, no formal complaint has been received by the manufacturer from PCOs. The writer, working both in the laboratory and in the field for more than a year, has experienced no ill effects from working with the compound. There have also been no formal complaints or objections made to the writer by occupants of establishments in which the dust has been field-tested. The writer has experienced some short-lived nasal and throat irritation when applying the compound without wearing a dust mask, but this also occurred when non-fluoride-impregnated silica compounds were applied without wearing a mask. The use of a respirator is, therefore, recommended for operators as protection against local irritation and general discomfort that comes with working with any dust in a confined area.

Limited toxicity studies have

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Table 7. Field experiments on the use of SG 77 and Dri-Die 67 for the control of German Cockroaches.

Location	Infestation	Material and quantity used (pounds)	Areas dusted	Date dust applied	Results (No live roaches seen after date given)
One-story apt., Los Angeles	Heavy	SG 77—2	Kitchen, living room, bathroom, bedrooms	4-29-58	6-29-58
Sanitarium, Long Beach	Moderate	Dri-Die 67—1	Kitchen, store room	5-28-58	5-28-58
Public Library, Glendale	Moderate	Dri-Die 67— ½	Kitchen	6-3-58	6-3-58
One-story home, East Los Angeles	Heavy	Dri-Die 67—3	Kitchen, service porch, bathrm., living room, dining room, bedrms.	6-5-58	7-5-58
One-story home, Malibu	Moderate	SG 77—2	Kitchen, living room, service area, bedrms.	6-6-58	6-29-58
Restaurant, Santa Monica	Moderate	Dri-Die 67—2	Eating area, serving area, bake shop, dish-washing area, storage area	6-7-58	6-20-58
Two-story apt., Los Angeles	Moderate	Dri-Die 67— ½	Kitchen	8-8-58	8-28-58
Two-story duplex (lower) Echo Park	Heavy	Dri-Die 67—1½	Kitchen, service porch, bathroom, hallway, bedroom	8-18-58	9-22-58
One-story home, West Los Angeles	Moderate	Dri-Die 67— ¾	Kitchen, bedrooms, bathrooms	8-28-58	8-28-58
Two-story duplex (upper) Lynwood	Heavy	Dri-Die 67— ¾	Kitchen, bathroom	9-2-58	9-10-58
Two-story duplex (lower) Lynwood	Moderate	Dri-Die 67— ¾	Kitchen, bathroom, shop	9-2-58	9-22-58
Sanitarium, Bldg. No. 1, Long Beach	Moderate	Dri-Die 67— ¾	Kitchen, bathrooms, bedrms., living rm.	9-15-58	9-15-58
Sanitarium, Bldg. No. 2, Long Beach	Moderate	Dri-Die 67—1	Kitchen, bathrooms, bedrms., living rm.	9-15-58	9-15-58
Two-story duplex (upper) Echo Park	Moderate	Dri-Die 67— ¾	Kitchen, work room, service porch	9-22-58	9-22-58
Two-story apt., Long Beach	Light	Dri-Die 67— ¾	Kitchen, bedroom, closets, stairwell	11-18-58	11-24-58
Two-story apt., Long Beach	Moderate	Dri-Die 67— ¾	Kitchen, bedrooms, closets, stairwell	11-18-58	11-24-58
One-story apt., Long Beach	Moderate	Dri-Die 67— ¾	Kitchen, bedrooms, closets, stairwell	11-18-58	11-24-58

been conducted with Dri-Die 67 on laboratory animals.

The acute oral LD_{50} for male albino rats is greater than 3160 mg. of Dri-Die 67 per kg. of body weight. The acute dermal LD_{50} for albino rabbits is greater than 3160 mg. of Dri-Die 67 per kg. of body weight. Dri-Die 67 gives evidence of being poorly absorbed and produced only a transient mild-to-moderate degree of irritation. There was no evidence of systemic toxicity from percutaneous absorption. A single application of 3 mg. of Dri-Die 67 to the eyes of albino rabbits produced a mild degree of irritation. This subsided completely within 48 hours after application.

Mice, rats, and guinea pigs were exposed for 6 hours to the dust of Dri-Die 67 at a concentration of 0.0473 mg. per liter (approximately 19.3 ppm), without evidence of toxicity.

Male albino rats were fed 2,000, 10,000, and 50,000 ppm (changed to 25,000 beginning on the fifth day) Dri-Die 67 for a period of 28 days. Survival, body weight gains, and food consumption were unaffected at the lowest dosages, while the highest dose produced alteration of body weight and food consumption (food refusal appeared to be responsible for this latter find). Autopsies revealed no gross pathology which could be attributed to the dietary feeding of Dri-Die 67.

From these limited studies it appears that Dri-Die 67 is a relatively non-toxic material when administered as a single dose by the oral, dermal and inhalation routes and when fed for 28 days at dosages of up to 1% in the diet.

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"GOOD HOUSEKEEPING" is the key to cockroach control and it applies just as much to the restaurant and commercial establishment as to the home. At best, the most efficient insecticide can give only temporary control if some measure of cleanliness and neatness is not observed along with insecticide application.

The cleaner and neater the establishment and the more effort expended in keeping it so, the easier the task of control. Therefore, prior to the application of any insecticide, it is of prime importance that all areas to be treated be cleaned thoroughly so no food particles and scraps, debris, dust, and clutter remain anywhere to foster cockroach infestation.

Various types of dusting equipment may be used. A hand duster, such as the Getz gun, bulb type hand duster, or polyethylene duster, may be used around the home or in restaurants and other eating establishments for the application of the dust under appliances, in cabinets and drawers, under sinks, on shelves, etc. However, for the application of the dust in large cracks and holes, in incinerators, waste bins, etc. a larger hand duster such as the Admiral-Hudson Duster No. 766 may be used. For dusting attics, large incinerators, sub-floor areas or other large surface areas, an electric duster such as the Tornado Electric duster is easiest to use.

Quantity

As stated in the article on pg. 14, a cockroach does not have to get a great quantity of Dri-Die 67 on its body in order for the dust to be effective, but experience has proved that it is necessary to put down what may seem like a comparatively large amount of the dust to insure that all cockroaches are killed in the shortest possible time. It is recommended that ¾ to 1 pound of material be used per 1,000 square feet of total floor area in an infested home, apartment, or business establishment. This is a sufficient amount for dusting all shelves; cabinets; cupboards; baseboards; moldings; and areas under, around and behind appliances, furniture, etc. The same quantity per 1,000 sq. ft. would be needed for dusting attics or sub-floor areas.

The degree of infestation largely determines just where the dust should be applied. In a very heavily infested establishment every room, the attic, all possible between-wall areas, the entire sub-floor or basement, under porch areas, and the garage should be dusted. Moderate to moderately heavy infestations usually are confined to the kitchen-utility room area and bathroom, so only these areas need be dusted in such cases, unless cockroaches have been seen elsewhere in the building. Where there is a very light infestation, the kitchen may be the only area that needs treatment. This decision can be made only after careful observations to determine where the cockroaches are living and breeding. The detailed procedures below are essential for control in a moderately to heavily infested establishment. For lighter infestations the procedures could, of course, be modified.

Prior to the application of Dri-Die 67 for cockroach control, all cupboards, drawers, closets, chests, stoves, etc. should be emptied completely, even lining paper should be removed. Drawers, chopping and bread boards, and flour, sugar and vegetable bins should be removed from all cabinets. Tightly cover all food items if they are in the area being dusted. Drawers from dressers, vanity tables, bureaus, chests, built-in cabinets, etc. should be taken out. All boxes, suitcases, trunks and clothing bags should be emptied outdoors. Cockroach-infested contents and containers should be cleaned, washed, or at least brushed thoroughly. If possible, the bathroom medicine cabinet and any other removable wall cabinets in the kitchen or elsewhere should be removed prior to dusting, so the dust may be applied between the walls.

The dust should be left on shelves, in cabinets, in drawers, under stoves, refrigerators, and other appliances indefinitely. Shelves and drawers should be lined with fresh shelf paper laid on top of the dust. The dust in conspicuous places, such as around floor baseboards, should be left for several days at least. Dust that has accidentally been dampened need not be replaced. The dust is odorless and will not stain or damage fabrics, painted surfaces, floors, etc. When necessary or desirable to remove the dust, the bulk of it can be picked up with a vacuum cleaner and the remainder on washable surfaces may be removed with soap and water.

Results of Dusting With Dri-Die 67

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the dust flushes out many cockroaches that otherwise would remain in hiding. By the beginning of the second week, however, most of the flushed-out cockroaches will be dead and there will be a decrease in the number of late-stage nymphs and adults. Young nymphs however, may still be seen. This is due to the fact that, like most insecticides, Dri-Die 67 has little effect on the oothecae (egg sacs) and some may be deposited during treatment, making it possible to find young, newly-emerged cockroaches several weeks to several months (depending on species) after all adults have died. Thus, it is essential to leave the dust in every possible area until all cockroaches have disappeared, regardless of how long this may be. In concealed places it is advised that the dust be left permanently.

The most important thing to remember in using Dri-Die 67, is that it is absolutely necessary that the material be placed in all areas where cockroaches are apt to be found. Though it may take somewhat longer to apply the compound thoroughly, the results and the long-lasting effectiveness will more than pay for any extra effort and time put in when applying it. Additionally, since Dri-Die 67 is so light, giving so much greater coverage than conventional dusts, the additional material cost is negligible. All the laboratory and field experience of the writer, plus the additional experience of other researchers and PCO's conclusively show that if this compound is applied properly as suggested, control is certain.

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ROACH RESISTANCE

What Is It?

Where Will It End?

by DR. C. C. ROAN

Department of Entomology, Kansas State University
Manhattan, Kansas

IF WE ACCEPT insecticide resistant insects as an established fact, then we may logically ask how all of this came about. For my part, I prefer a simple explanation. Resistant individuals have always been present to a greater or lesser extent but have not manifested themselves because their numbers were overshadowed by the relatively enormous preponderance of what we presently call "normal" individuals. But now, the insecticidal suppression of the "normal" population has allowed the resistant individuals and their offspring to prosper and claim our attention.

This explanation, if validated, would lead us to anticipate a more rapid appearance of resistance in those species with short life cycles and frequent generations.

Just as anyone familiar with insects knows that the problems of controlling each species are quite different, so he should expect similar differences in the characteristics of the various insecticides and the results that can be obtained from them.

There are three major categories of insecticides:

1. Chlorinated hydrocarbon insecticides:

   a. DDT, methoxychlor, etc.

   b. BHC, dieldrin, chlordane

2. Organic phosphorus insecticides.

3. Botanical insecticides.

The first two categories appear to be of most interest to the pest control operator.

Among the chlorinated hydrocarbons, DDT and related compounds appear to be involved in cross tolerances with respect to insecticide resistant insects. The same may be said for the BHC-chlordane complex. In the case of house flies, resistance to the chlorinated hydrocarbons does not particularly appear to predispose the insect to a tolerance or resistance to the organic phosphorus compounds.

A curious anomaly is observed here, however. Continuous organic phosphorus insecticide pressure will generally produce resistance to the phosphorus compound and also a high order of resistance to several of the chlorinated hydrocarbon insecticides, particularly DDT.

Physiological, Behavioral Resistance in Roaches

Control failure may result, generally speaking, from the insect's failure to die from contact with a previously lethal chemical, or failure of the insect to contact a lethal amount of the chemical. This latter phenomenon I would call behavioral resistance; the former would be physiological resistance.

The PCO should be just as concerned with potential behavioral resistance as he is with the physiological type.

It is important here to point out a frequently overlooked fact. We speak of DDT, chlordane, malathion, etc., but these materials are used in control operations as formulations of one sort or another. Particularly with respect to real or potential behavioral resistance, we should not overlook the probable effects of the solvents, surface active agents, carriers, and other additives used in the formulation. There is some indirect evidence to indicate that these compounds may be involved in behavioral responses such as avoidance reactions, etc.

In cockroaches, we are concerned with a developed resistance as contrasted with natural resistance. Some people talk of a natural resistance in certain species of insects. This term is generally applied to situations where the insecticide would not control the species in question from the beginning.

What to Do About Resistance

If we restrict our consideration to household pests and assume that we have insect resistance to an insecticide, what then? The answer is simple: select an alternate insecticide, preferably not too closely related chemically to the first. Assure thorough and adequate treatment. Be certain that steam cleaning or other routine operations of your client are not removing or inactivating the treatment before it has had an adequate opportunity to exert its action. Do not overlook the possibilities of an alternate formulation instead of an alternate insecticide.

If alternate insecticides are the answer, then you may well ask how long can this go on? This is not easy to answer, but there is every reason to be optimistic. New materials, although appearing less frequently now, will continue to be developed. Repellents, or more probably attractants, appear promising. The potential use of bait sprays are particularly of interest for the household insect control field. But before blaming resistance, be sure you exhaust all other possibilities.

It is unfortunate the answer above is all we have at the present. Until we know more about how insecticides kill insects—i.e., their mode of action—we are in a relatively poor position to explain why they do not kill insects. To achieve even a partial understanding of the mode of action of insecticides will require a great deal more research.

Based on a paper presented at the 1959 Purdue University PCO Conference.

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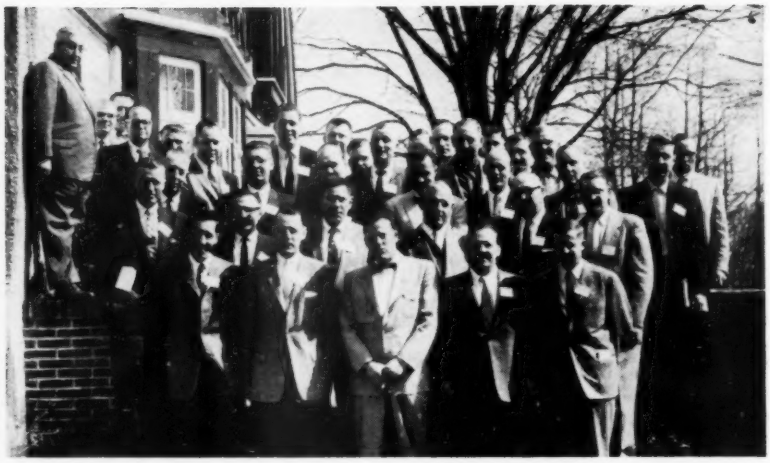

Out of the schoolroom, into the sun — MSU Conference delegates between classes.

Watch Winds, Water Sanitation in Area Mosquito Control, MSU PCO Conference Told

Chemical application is not the only important phase of area mosquito control. The operator must also undertake "water sanitation" where mosquitoes breed, Dr. R. L. Janes of Michigan State University stressed at MSU's annual Pest Control Conference recently. The two-day meeting was held at the Kellogg Gull Lake Biological Station.

"Wind conditions in the area of the breeding grounds must also be considered since air currents affect the distribution of mosquitoes," Dr. Janes said. "Where winds are continuous, a residual spray approach may not be the best answer since such a program is limited to rather small areas, whereas the water area may be rather expansive and require frequent treatments. This might be impractical.

"Another strong influence on control is the surrounding area to which the insecticides may drift. Where there are forage crops nearby a mosquito project may be impractical since drift of pesticides could not be kept from the crops."

Dr. Janes said it is impossible to forecast the best dates for mosquito control projects, since hatching is influenced by temperature and moisture. Hatching may be delayed or speeded up by changes in these environmental factors.

Dr. J. R. Hoffman of MSU's Department of Entomology suggested control of mosquitoes and flies around homes with chlorinated hydrocarbon insecticides could possibly contribute to a build-up of clover mites, a nuisance pest. The use of miticides plus a barrier strip around the foundation of a home is an effective control weapon, he said.

"Control should be started early before the mites enter the house," Dr. Hoffman stated. "Their natural habitat is frequently in the foundation plants around housing, as well as on other ornamental plants, and in lawns."

Drs. Hoffman and Janes joined a panel of PCOs in another session devoted to resistance. On the panel with them were John K. Spyre, of John K. Spyre Pest Control, Royal Oak, Mich.; Joe Watkins, Vogel-Ritt of Michigan, Inc., Detroit; Harry Sinclair, Sinclair Exterminating Co., Lansing, Mich.; and Ivan Rogner, Dobson Pest Control, Bay City, Mich.

Although stainless steel or other metal used in kitchen fixtures may be easy to keep clean, operators complained during the panel discussion that the design of the fixtures often leads to roach infestations which the PCO cannot eliminate. This is because there is no means of access to the confined or enclosed areas of such "floor-tight" fixtures harboring the insects.

Another panel covered miscellaneous pests and their control. On it were Dr. Ray Hutson of MSU's Department of Entomol-

(Continued on page 63)

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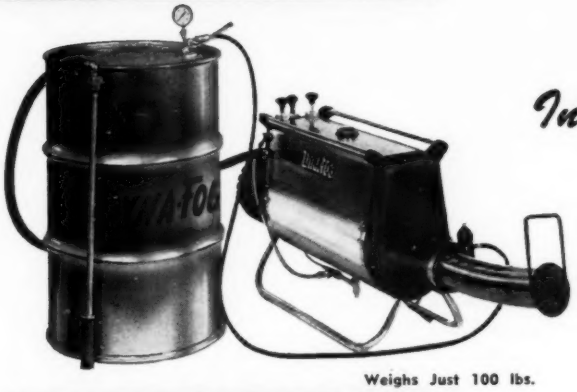

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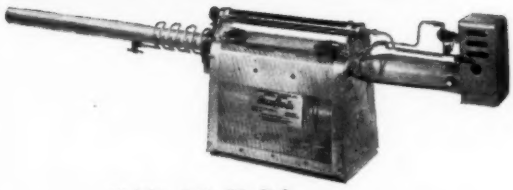

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SUMMARY

Cooperative studies were carried on during 1955-56 with a chocolate manufacturer, to study the fumigation of bulk-stored cocoa beans to control the moth *Ephestia elutella* (Hbn.). In laboratory studies, concentration-time curves for several application rates of methyl bromide to bulk cocoa beans were developed. A rate of 2 ounces per 1,000 cubic feet killed all stages of the moth with a 24-hour exposure, a rate of 4 ounces gave complete mortality in 12 hours, and a rate of 8 ounces in 4 hours. Displacement was greater than sorption in the early part of the exposure period so that the concentration curve began at a point higher than the application rate and ended at a point not far below it. The rate of sorption was approximately the same at application rates of 2, 4, 8, 16, 24 and 32 ounces.

Methyl bromide applied by gravity penetration at a rate of 2 pounds per 1,000 cubic feet to a 93-foot upright elevator bin filled with cocoa beans penetrated rapidly to the lower part of the bin, and sampling points along the walls in the upper half had concentrations too low to kill the moths on the basis of the curves developed in the laboratory study. When the same dosage of methyl bromide was recirculated in this bin by using a return duct, the distribution was much more uniform and was several times the lethal concentration at all sampling points. When the gas was recirculated through two loaded bins instead of using a return duct on one bin, the distribution was fairly uniform except at the beginning of the cycle at the top of one bin where an area of low concentration developed. It was assumed that additional recirculation would have corrected this situation. A short period of aeration removed the fumigant at the end of the exposure period.

Bulk Cocoa Bean Fumigation

For Tobacco Moth:

Gravity Penetration Vs. Recirculation

by G. L. PHILLIPS[1], W. K. WHITNEY, C. L. STOREY and H. H. WALKDEN

Stored-Grain Insects Laboratory[2]

Manhattan, Kansas

THE cocoa or chocolate moth *Ephestia elutella* (Hbn.), whose approved common name is actually the "tobacco moth," is a serious pest of cocoa beans that remain in storage for long periods. The beans are frequently infested when received at the storage warehouse, and infestation increases while the commodity remains in storage.

A cooperative study[3] was inaugurated in the summer of 1955 with the Walter Baker Division, General Foods Corporation, Dorchester, Mass., to study the use of the recirculation method of applying methyl bromide to cocoa beans stored in upright silo-type bins. The efficiency of the currently used method of distributing methyl bromide by gravity penetration of the dosage released in the headspace of the bin was not too satisfactory.

The studies were composed of two parts which were carried on concurrently. Manhattan, Kans., laboratory studies were made to determine the amount of sorption of the fumigant by cocoa beans and to develop concentration-time curves against which gas concentration readings in commercial fumigations could be matched. At Dorchester, Mass., exploratory fumigation tests were made in loaded bins holding approximately 1½ million pounds each, to study the distribution of methyl bromide gas when recirculated through the loaded bins.

The Walter Baker Division authorized the fumigation experiments using methyl bromide as the fumigant only after having adequate tests made by a reliable laboratory. This was done to be certain that the bromide residues would be well below the safe tolerance established by the U. S. Food and Drug Administration.

Laboratory Tests at Manhattan

Procedure

The amount of gas sorption by cocoa beans and the dosage-time relationships that produced complete mortality of all stages of the cocoa moth were developed in studies at the Manhattan laboratory under carefully controlled

1. G. L. Phillips is now located at the Stored-Product Insects Laboratory, Lee Hall, Va.
2. This is one of the field stations of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.
3. These cooperative studies were arranged by C. A. Clark, Sanitation Coordinator, General Foods Corporation. E. A. Sanstrom, Manager, Manufacturing and Engineering, and M. J. Doyle, Plant Sanitarian, Walter Baker Division, Dorchester, Mass., participated in the tests at Dorchester. R. L. Ernst, of the Stored-Grain Insects Laboratory staff, also assisted in the 1956 test at Dorchester.

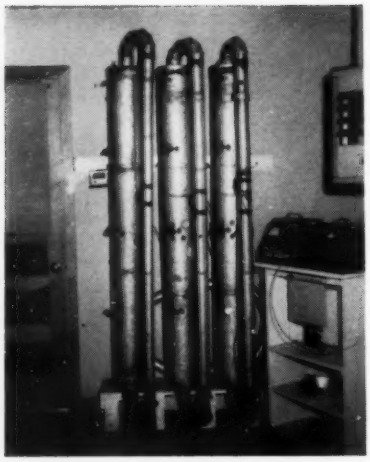

Fig. 1 — Test chambers for recirculating the fumigant through the cocoa beans.

conditions. Three small experimental fumigation chambers (figure 1) equipped to recirculate a fumigant through a commodity, which are used routinely for the evaluation of candidate fumigants,[4] were utilized for these studies. Each chamber was 6 feet tall and 8 inches in diameter, with a 3-inch return duct leading from a screened opening in the flat bottom, through the fan to the headspace. All joints were sealed so that the chambers were gas-tight. The walls of the chamber were provided with a number of holes through which insect cages could be inserted or withdrawn. The holes not in use were effectively sealed with neoprene stoppers. Permanent copper gas sampling tubes were soldered in the chamber walls. Experience had shown that methyl bromide could be uniformly distributed through a column of a commodity such as grain with about 10 minutes recirculation, and that the gas concentration would remain the same in all parts of the load from that point on. Each chamber held 82 pounds of cocoa beans. The chambers were located in a laboratory kept at approximately 75° F. at prevailing atmospheric pressures and at relative humidities ranging between 25 and 30 percent.

In tests to study the sorption of gas by the cocoa beans, application rates of 2, 4, 8, 16, 24 and 32 ounces of methyl bromide per 1,000 cubic feet were used. The rate of application was the same in all three test chambers in a given test, thus giving three replications under identical conditions. The gas concentrations were determined at 10 minutes, 4, 8, 12 and 24 hours, by drawing a gas sample, circulating it through a thermal conductivity gas analyzer unit, then returning it to the test chamber.

The dosage - time relationships were made by exposing the various stages of the moth in the above tests until a point was reached where complete mortality was obtained at the shortest exposure period (4 hours), which was at the 16-ounce application rate. In each test related to insect mortality, five sets of cages containing 24- to 48-hour old eggs, mature larvae, pupae, and young adults of the moth were prepared, each cage containing only one stage of the insect. One set each was withdrawn after 4, 8, 12 and 24 hours' exposure to the fumigant and one was held as a check. After exposure the insects were returned to the culture room until mortality counts were made. Adults were observed after 2 days, larvae after 5 and again after 30 days, eggs after 10 days, and the pupae held for 30 days and the emerging adults counted.

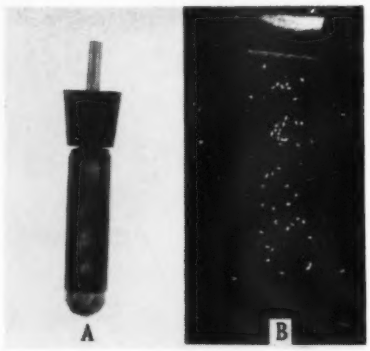

Fig. 2-A — Test cages of wire mesh used to confine the test insects in the test chamber during fumigation. **Fig. 2-B** — Adhesive tape used to facilitate handling of the eggs during fumigation tests.

The insects were reared in a culture room maintained at 80° F. and 60 percent relative humidity. Food was provided for the larvae to keep cannibalism at a minimum. About 30 eggs and from 10 to 15 each of the other stages were used in each screen-wire cage (Figure 2A). A special technique was devised to hold the eggs during the test period. Short pieces of ½-inch electrician tape were cut and the edges folded in so that a strip of the adhesive was left exposed in the middle (Figure 2B). The folded edge permitted handling without the tape sticking to the fingers. The eggs were placed on the adhesive with a camel's hair brush where they remained attached during subsequent handling and incubation without any apparent detrimental effect.

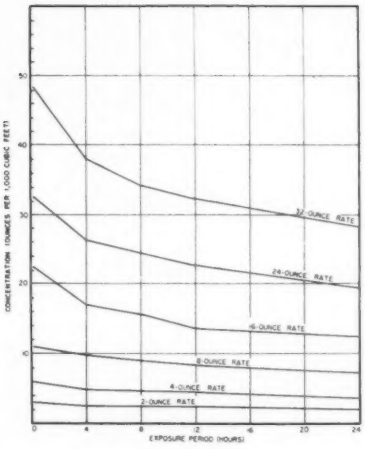

Fig. 3 — Concentration curves for various application rates of methyl bromide applied to cocoa beans.

Results

The concentration curves based on gas analysis readings at the

Concentration Curves Based On Gas Analysis Readings

Application rate	Percentage of application rate present at				
	10 Minutes	4 Hours	8 Hours	12 Hours	24 Hours
2 Ounces	150	130	125	117	100
4 Ounces	150	120	113	113	88
8 Ounces	140	123	115	105	91
16 Ounces	140	107	98	87	78
24 Ounces	140	110	102	95	81
32 Ounces	152	119	107	101	88
Average	145	118	110	104	88
In empty chamber	96	93	91	88	86

4. Dennis, N. M., and W. K. Whitney. Screening procedure for candidate fumigants for stored grain and grain products. U. S. Bur. Ent. and Plant Quar. Pub. E-878. May 1954.

Table 1.—Mortalities of stages of the cocoa moth produced by various application rates and exposure periods.

Application rate and length of exposure period	Adults	Eggs	Larvae	Pupae
2 Ounces per 1,000 cubic feet	Percent	Percent	Percent	Percent
4 Hours	100	45	47	2
8 Hours	100	91	87	33
12 Hours	100	100	98	82
24 Hours	100	100	100	100
Control	57	25	38	7
4 Ounces per 1,000 cubic feet				
4 Hours	100	72	98	40
8 Hours	100	99	100	100
12 Hours	100	100	100	100
24 Hours	100	100	100	100
Control	20	6	38	0
8 Ounces per 1,000 cubic feet				
4 Hours	100	100	100[1]	100
8 Hours	—	100	100[1]	100
12 Hours	—	100	100	100
24 Hours	—	100	100	100
Control	13	5	60	10
16 Ounces per 1,000 cubic feet				
4 Hours	100	100	100	100
8 Hours	100	100	100	100
12 Hours	100	100	100	100
24 Hours	100	100	100	100
Control	42	2	46	7

[1] There were a few survivals in the 5-day examination that died before the 30-day examination.

10-minute, 4-, 8-, 12-, and 24-hour periods for the respective application rates of 2, 4, 8, 16, 24 and 32 ounces of methyl bromide per 1,000 cubic feet are presented in figure 3. The amount of sorption by the cocoa beans was less than displacement in the early part of the exposure period so that the concentration curve started at a figure greater than the applied rate and ended at a figure not too far below the applied rate. Furthermore, the rate of sorption was approximately the same for each application rate, as would be logically expected. The percentages of each application rate present at each sampling period are tabulated at the bottom of the opposite page, based on the same data as figure 3.

The mortalities of the various stages of the moth produced by 4-, 8-, 12- and 24-hour exposures with 2-, 4-, 8- and 16-ounce application rates are given in table 1. All insects were killed at the 2-ounce application rate by 24 hours' exposure, at the 4-ounce rate by a 12-hour exposure, and at the 8- and 16-ounce rates by a 4-hour exposure. A few larval survivors at the 5-day examination at both 4- and 8-hour exposures with the 8-ounce rate died later. The adults were most susceptible, followed in order by the eggs, larvae, and pupae.

Concentration - time curves for the application rates of 2, 4, and 8 ounces for exposure periods of 24, 12 and 4 hours, respectively, are presented in figure 4. These curves will later be compared with concentration curves obtained at sampling points in the fumigation tests in loaded upright bins.

Tests in Upright Bulk Storage Bins

Procedure

The tests to study gas distribution in loaded, upright, bulk storage bins at Dorchester, Mass., were made in May and June 1955 and again in May 1956, at a time when there was little natural infestation in the cocoa beans. The results were based on gas concentration readings.

The first two tests in May and June 1955 were made in the same bin, which was 93 feet high by 24 feet in diameter with a flat bottom, and contained 42,000 cubic feet. This bin was loaded with 1,500,000 pounds of cocoa beans. Cables of ¼-inch plastic gas sampling tubes were formed, with one tube ending at each 15 feet. Three of these cables were placed in the bin from top to bottom before it was loaded. One down the center was attached to the cable of the temperature recording system, and one down the west wall was attached to a spiral trough used to feed beans into the bin to prevent breakage. The third one was suspended down the west wall. The terminals of individual lines were arranged so that three gas samples could be taken across the bin at levels of 15, 30, 45, 60, 75 and 90 feet deep.

In the first test, the methyl bromide dosage, at the rate of 2 pounds per 1,000 cubic feet, was released in the headspace at the top of the bin and distributed by gravity penetration. This method had been used for some time at this plant. Gas concentrations were read on a thermal conductivity gas analyzer at ½, 1, 2, 4, 8 and 24 hours.

In the second test, in the same bin, the methyl bromide was distributed by recirculation. The gas was withdrawn from the bin through a cross-shaped floor duct made of two inverted 10-foot sections of 9-inch conveyor housing placed end to end across the diameter of the bin, and two sections of 6-inch housing end to end placed at right angles to the 9-inch housing. This arrangement is diagrammed in figure 5. A section of 6-inch connecting duct was inserted through the floor at one end of the 9-inch floor duct. A temporary return duct was formed of 10-inch flexible duct, and was fastened to the outside of the bin. This led from the floor connection to the headhouse, and

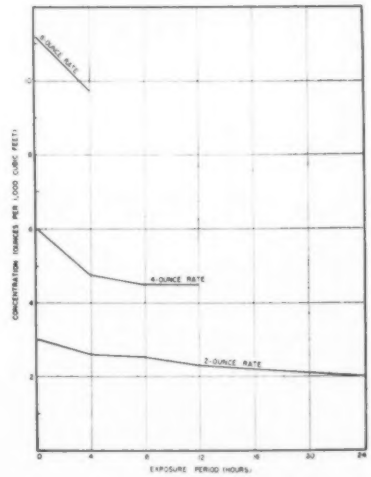

Fig. 4 — Concentration-time relationships that produced complete mortality of all stages of the cocoa moth in controlled tests.

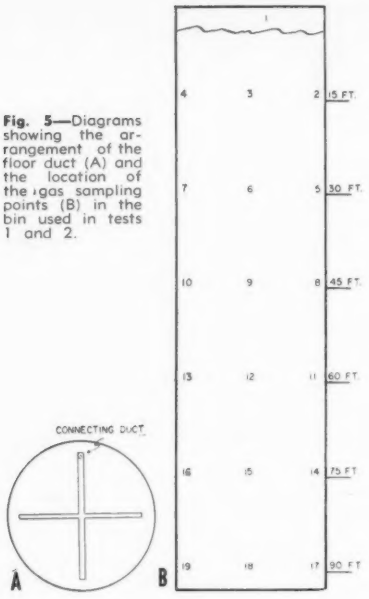

Fig. 5—Diagrams showing the arrangement of the floor duct (A) and the location of the gas sampling points (B) in the bin used in tests 1 and 2.

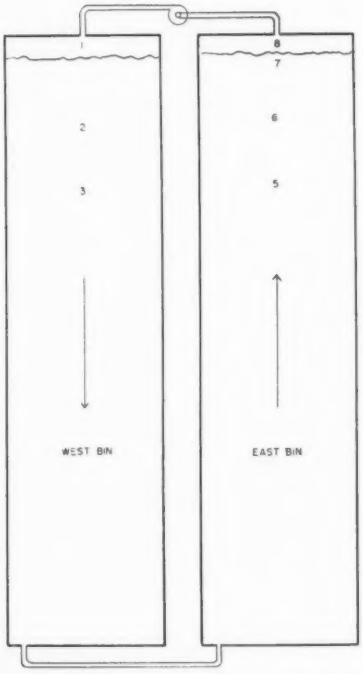

Fig. 6 — Diagram showing the recirculation system, and the sampling locations in test No. 3.

terminated at a 30-inch blower driven by a 7-hp. electric motor. Another length of flexible duct connected the blower to headspace and was sealed into an opening in the top manhole. The air-flow direction was downwards through the load of cocoa beans. There was considerable resistance in this system, mainly because of the spiral corrugation in the flexible duct used as the return duct, so that the blower delivered only 1,200 c.f.m. and the flow rate was 0.008 c.f.m./cwt.

The dosage of methyl bromide was sprayed into the headspace while the air was being recirculated, and because the nozzle used was too small, the time required was nearly 1 hour. The air-gas mixture was recirculated for 1 hour, including the time required to apply the dosage. Gas concentrations were read at ½, 2, 4, 8 and 24 hours. At the end of 24 hours, the bin was aerated by operating the system for 40 minutes with the blower discharge diverted to the open air.

A third test was made in May 1956 to explore the possibilities of dispensing with the return duct, and using a second bin instead. Two bins loaded with 1,486,500 and 1,361,600 pounds of cocoa beans, respectively, were connected at the bottom and at the top, and the same 30-inch blower used in the second test was inserted in the connection between the tops of the bins. Each bin had a floor duct similar to the one used in the second test and the two duct systems were connected with a length of 10-inch flexible duct (figure 6). The air flow rate in this system was not measured, but it was evident that the resistance was greater than in the second test. Gas sampling points were established in the headspace, and 10 and 20 feet deep in the top of the west bin, which was the beginning of the cycle; in the connecting duct between the bottoms of the tanks; and at the 20-, 10-, and 1-foot levels and in the headspace of the east bin, which was the end of the cycle. The gas sampling points were selected after the bins were loaded. Probes were inserted down the center of each tank to depths of 10 and 20 feet to draw gas samples from those levels.

Methyl bromide was applied at the rate of 2 pounds per 1,000 cubic feet with the blower in operation and gas concentration read-

Table 2.—Concentration of methyl bromide per 1,000 cubic feet present at sampling points in the bin of cocoa beans after application by gravity penetration, and recirculation using a return duct.

Location of sampling point	Gravity penetration						Recirculation				
	½ hour	1 hour	2 hours	4 hours	8 hours	24 hours	½ hour	2 hours	4 hours	8 hours	24 hours
Headspace	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Above load	90	40	19	10	6	4	35	26	20	18	11
15 feet deep											
East wall	2	9	0	5	4	3	46	28	20	18	12
Center	8	5	2	10	8	4	50	40	24	18	11
West wall	0	2	2	2	1	2	29	25	22	18	11
30 feet deep											
East wall	0	0	0	6	6	5	44	40	32	17	12
Center	3	66	35	22	14	4	36	33	25	18	12
West wall	0	0	0	2	0	3	24	25	20	19	11
45 feet deep											
East wall	0	0	0	10	12	9	52	34	31	20	10
Center	2	2	4	6	4	2	36	26	28	22	12
West wall	0	0	0	3	2	6	22	25	19	17	10
60 feet deep											
East wall	2	0	0	13	17	12	38	32	20	20	10
Center	18	0	0	10	11	6	34	20	24	23	12
West wall	2	0	0	2	10	11	18	22	16	14	9
75 feet deep											
East wall	0	0	3	20	21	13	38	27	25	16	10
Center	0	8	6	24	24	12	—	—	—	—	—
West wall	0	0	0	46	17	13	16	19	15	12	8
90 feet deep											
East wall	0	50	56	48	37	17	29	25	25	17	9
Center	0	52	45	42	32	18	26	17	22	20	11
West wall	0	0	47	14	30	14	6	16	13	12	6

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Table 3.—Concentration of methyl bromide present at sampling points in the two connected bins of cocoa beans following application of the fumigant by recirculating it through the two bins.

Location of sampling point	Gas concentration per 1,000 cubic feet after—				
	½ hour	2 hours	4 hours	8 hours	24 hours
Beginning of cycle	Ounces	Ounces	Ounces	Ounces	Ounces
1. Headspace, west bin	8	6	6	10	6
2. 10 feet deep, west bin	2	0	0	0	0
3. 20 feet deep, west bin	40	44	20	14	10
Between bins					
4. Connecting duct	28	22	36	34	13
End of cycle					
5. 20 feet deep, east bin	37	23	15	12	10
6. 10 feet deep, east bin	30	18	13	12	5
7. 1 foot deep, east bin	16	13	11	9	8
8. Headspace, east bin	20	18	13	12	9

ings were made at 15-minute intervals until they were less at the beginning of the cycle than at the end, then the blower was stopped. The total time of recirculation was 50 minutes. Readings were then taken at ½, 2, 4, 8 and 24 hours. At the end of the 24-hour exposure period, the blower was operated for 2¼ hours to remove the fumigant from the beans.

Results

The concentration readings at the sampling points in the bin where methyl bromide was first distributed by gravity penetration, then by recirculation using a return duct, are presented in table 2. In gravity penetration the gas rapidly moved to the lower part of the bin, more or less in a channel down the center, as indicated by the concentration readings at the 30-minute period for the center sampling point down to 60 feet deep, and the 1-hour readings to the bottom. The concentration continued to build up in the bottom half of the bin, but the areas near the wall in the top half were largely by-passed. When the gas was distributed by recirculation, the concentrations were excellent at all points in the top half of the bin at the 30-minute sampling period, and fairly uniform all over the bin at the 2-hour period, ranging from 16 to 40 ounces per 1,000 cubic feet. This uniformity of distribution remained throughout the exposure period.

The gas was readily removed by aerating the bin at the end of the exposure period. The blower was not operated long enough to remove all gas, but 40 minutes' aeration reduced the concentration to 2 ounces or less.

The concentration readings at the sampling point at the beginning and end of the cycles where the gas was distributed by recirculation through two loaded bins are given in table 3. The gas was distributed throughout the two bins by 50 minutes' recirculation. The resistance at the beginning of the cycle was great enough to cause a build-up of pressure in the headspace of the west bin, which resulted in some loss of gas even though the ventilation openings and manholes had been sealed. This was reflected in the low concentration at the beginning of the cycle. During the early part of the recirculation period, sampling points 1 and 2 in the west bin showed high concentrations, and these later decreased near the end of the period. This condition could be corrected by introducing the gas at a slower rate and over the entire recirculation period.

The fumigant was readily removed by aeration at the end of the exposure period. All sampling points except 5 and 6 showed no gas after 2¼ hours' aeration and these two points showed readings of 2 ounces. The aeration was continued but no further readings were made.

Discussion

The gas concentration readings obtained in the first test by gravity penetration indicate that survivals might occur in the upper part of the bin due to the proclivity of the gas to concentrate in the bottom half of the bin. The more uniform distribution obtained in the second test by recirculation indicates that the application rate could be reduced considerably. When the concentration curve of each sampling point in the second test is compared with the curves developed in controlled tests as shown in figure 4, this fact is very evident. In the third test, all of the sampling points from 20 feet deep at the beginning of the cycle (No. 3) on through the remainder of the cycle were several times the concentration level needed for complete mortality. The low concentration at sampling point No. 2 was apparently due to leakage. The 15-minute readings during the recirculation period had shown a progressive movement of high gas concentrations from the beginning to the end of the cycle, and the beginning of a decrease at the start of the cycle. Subsequent studies related to recirculating air through two loaded upright bins have shown that leakage can be minimized by placing the blower in the bottom connection between the bins so that the pressure build-up is all confined to the lower part of the second bin where there are no openings except the connecting duct.

Subsequent fumigations at the plant indicate satisfactory results with this method of forced recirculation of the fumigant.

Defense Sprays of Roaches

(from page 12)

seconds, open-mouthed and "pawing" its tongue.

Eurycotis and *Neostylopyga* also repelled some of the smaller arthropod predators, but somewhat less effectively than did *Diploptera*. Larger predators such as birds, lizards and frogs were also usually repelled, the effect being especially dramatic in cases where some secretion had hit the eyes. A blue jay, after having received the full impact of a *Eurycotis* discharge, was seen to maintain one eye closed for a full ten minutes following the encounter. Similarly, a lizard, after making a "pass" at a *Neostylopyga*, dug its head in the sand, and rubbed it back and forth in obvious discomfort. We ourselves have been sprayed in the eyes and can attest to the sharp pain that this entails.

Not all results were as clear cut as these. Certain lizards were

found to eat *Diploptera* readily, suffering no immediate aftereffects. Yet, after eating these roaches for a few days, the lizards began ignoring them, shifting their attention instead to a more palatable insect, introduced as a choice at that time.

Other predators seemed to be completely unaffected by the sprays. Praying mantids for instance ate *Diploptera* and *Neostylopyga* when these were offered to them for the first time, and continued eating them indefinitely, without ill-effects, and without developing any long-term discriminatory tendencies against them (fig. 10).

The fact that these roaches differ somewhat in the effectiveness with which they repel the various predators is not surprising, since they do not secrete the same chemicals. Roth and his collaborators at Natick have identified the active principles of the secretions of *Diploptera* and *Eurycotis*. *Diploptera* secretes a mixture of quinones (*p* - benzoquinone, and two of its derivatives), whereas *Eurycotis* secretes an aldehyde (2-hexenal). The secretion of *Neostylopyga* has not yet been analyzed, but it is unquestionably distinct from that of the other two (It's odor, for one thing, is completely different).

A great deal is being done in several laboratories throughout the world on the chemical defense mechanisms of insects and other arthropods. Many of the active principles of the secretions have already been analyzed, and attempts are being made to evaluate their specific functions. Some of this work may ultimately be of practical value, inasmuch as it may provide clues as to what specific chemicals might be worth investigating in connection with the formulation of new or improved commercial repellents. In addition, some of the secretions have been found to possess rather powerful antibacterial action, a circumstance that is encouraging some laboratories to investigate their potential usefulness as medical antibiotics.

Basically, however, the main value of this research lies in its purely biological implications. It is clarifying some fundamental aspects of predator-prey relationships, and is therefore contributing to our understanding of biological competition in general. One of the conspicuous features of the present day land fauna is the evolutionary supremacy of arthropods, and of insects in particular. One cannot help but wonder whether the achievement of dominance was attributable to a significant extent to the possession of effective means of chemical defense. The widespread occurrence of these defense mechanisms would appear to lend at least some support to this contention. It is certainly an odd fact (and, one might add, a heartening one—at least to those of us whose interest in insects stems entirely from their suitability for biological research) that insects should have evolved a successful spray program all of their own, long before man first conceived of developing a counterpart.

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Home Building Speed-Up Helps Make Horntail A Pest In Structural Timbers

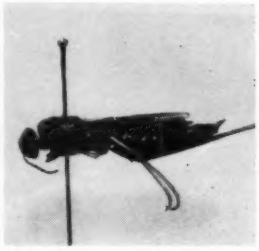
by DR. LELAND CHANDLER
Department of Entomology, Purdue University
Lafayette, Indiana

Within the past few years, the emergence of horntails from structural timbers has brought an increasing number of inquiries to Purdue. Most of these requests are for identification of the insects and for recommended control measures. To gain a better understanding of this relatively new problem, I would like to discuss it as a part of the total picture of horntail biology.

There are three major reasons for the increase of horntails emerging in homes. Briefly, these are: (1) the house building program in the United States has been expanding at an almost fabulous rate; (2) the percentage of pine and related softwoods, as building materials, has increased significantly; (3) the demand for lumber has been of such magnitude that it has depleted or seriously threatened our resources. Thus, there is now a trend toward the utilization of fire-damaged, diseased, or insect-killed or weakened trees. As will be pointed out, horntails attack weakened trees, and in the case of fires, are even attracted to these sites.

Classification and Identification

Horntails, or wood wasps as they are sometimes called, belong to the order Hymenoptera and are placed in the family Siricidae. The common name of horntail was given this group in reference to the long, stout ovipositor of the female but it is not entirely inappropriate for the male, which has a hard, triangular plate at the tip of the abdomen, or the larva, which bears a spine on the last abdominal segment. Horntails belong to that group of Hymenoptera, which includes the various sawflies, all of the adults in this group having the abdomen broadly joined to the thorax.



Horntail female of the pigeon tremex. (Photo by A. N. Kishaba)

Rohwer (1911) proposed the assignment of the genera to the two sub-families as they are recognized today. Bradley (1913) and Benson (1943) have followed this proposal and have strengthened it by the recognition of additional morphological and biological characters.

The subfamily Siricinae is characterized by the long, filiform antennae (17 - 25 segmented) which are set close together, by having the labial palpi 3-segmented and with cerci present. The species in this subfamily attack coniferous trees. Only one of the species has received a common name as approved by the Entomological Society of America[1], that being the blue horntail, *Sirex cyaneus* Fabricius.

There is much confusion as to the species which occur in North America. Recent catalogs (Muesebeck, *et al*, 1951; Krombein, 1958) list *Sirex* with 12 species, *Urocerus* with 5 species and *Xeris* with 2 species each of which is divisible into 2 subspecies.

The subfamily Tremicinae is characterized by having shorter antennae (less than 17 segments), the middle segments swollen and the antennae bases rather wide apart. The labial palpi are 2-segmented and the cerci are absent. The species in this subfamily attack deciduous trees. There is but a single species of this subfamily present in North America. This is the pigeon tremex, *Tremex columba* Linnaeus.

We have received horntail specimens and inquiries from Cleveland, Lima and Akron, Ohio; Detroit, Michigan; and, Milwaukee, Wisconsin. The species most often submitted has been the blue horntail, *S. cyaneus*, but there have been other species of *Sirex* and we have one record of the pigeon tremex, *T. columba*.

Species Biology

Chrystal (1928) remarked that no comprehensive accounts on the biology of American species attacking conifers had yet appeared. The same statement is true today. However, European workers have made excellent contributions to our knowledge of species biology and it is largely from these sources that this portion has been drawn.[2] It is significant that the species that are well-known in England are the same ones most often submitted to us for identification.

Adults

Emergence and mating. The dates of emergence and periods of adult activity differ according to the species concerned, or in the case of emergence from structural timbers, according to the immediate environment of the individual. Chamberlin (1949) stated that the larval period of a species may be prolonged for a year or more if infested wood is cut for lumber.

The sex ratio in all species

Presented at the 1959 Purdue University PCO Conference.

1. Bull. Ent. Soc. Amer. 1 (4)

2. Many of the original works cited by Chrystal (1928) and Benson (1943) have not been seen by this writer. Future workers in siricid biology will find the works of the above authors, and the bibliographies of each, the major sources of data.

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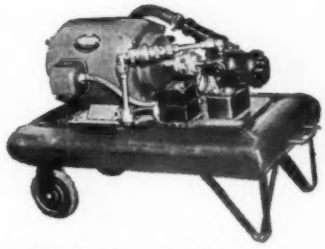

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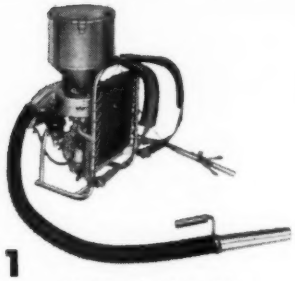

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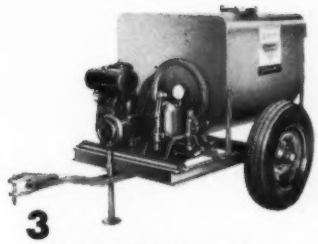

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studied in detail is predominantly in favor of females. Chrystal (1928) reported twice as many females as males of the blue horntail, *Sirex cyaneus* Fabr., and other authors have reported ratios of this, or greater, for this and other species. However, Johnson (1928) has reviewed the observations published by Raddon (1836) on *S. juvencus* in England who stated that during the emergence period, which extended over a period of several months, males outnumbered females 11:1 the first six weeks, the ratio gradually becoming more equal until only females were emerging during the last two or three weeks.

Mating has been observed only upon occasion. This may be explained by the fact that in those observations that have been made, mating pairs were found in tree tops. Since males have been observed flying at considerable heights and are not nearly so abundant in collections as are females, it would tend to support these observations and explain the apparent scarcity of males. Following mating, the female descends to the lower levels of the tree trunk for oviposition.

Chrystal (1928) cited several records made by some of the earliest observers concerning the adult food habits. It was formerly believed that the horntail adults were predators upon flies, moths, and other small insects. This predaceous habit attributed to the adults is now generally disregarded, but it does point out the fact that adult food habits are not known.

Dispersal

In forests which have been damaged by fire, horntails appear in very large numbers. It has been reported that on occasions where observations were made just after a fire and in areas where horntails were not previously present in any numbers, great numbers of females were observed flying into and about the area. Chamberlin (1949) has recorded females ovipositing in smoldering logs, logs that were too hot to be touched by the hand. The fate of the eggs laid under such circumstances was not determined. Graham (1939) stated that forests damaged by spring fires were more readily attacked than those forests damaged during other seasons.

One of the major problems in our understanding of horntails has arisen through the distribution of species by lumber shipments. It is now difficult to determine if certain species are native to an area or whether they were introduced and have become established in the area. Benson (1943) reported that timber was being imported into England from northern Europe in the 13th and 14th centuries. Cameron (1890) stated that "American species" were occasionally taken in England from railway stations, mine timbers, and other wood materials in areas where all of this suggested emergence from timber imported from America. Gillanders (1908) reported the emergence of horntails from mine timbers which had been brought from Canada. Bradley (1913) recorded the emergence of horntails in an

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Oviposition

Prior to ovipositing, the female makes repeated inspections of the wood with her antennae. According to Chrystal (1928), she will also probe the sites with her ovipositor. Selecting a place to oviposit, she raises herself upon the ovipositor sheaths, positions the ovipositor, releases the sheaths to their original horizontal position, and by rhythmic abdominal movements and the saw action of the ovipositor begins to drill into the wood. If one has ever examined the thin, flexible ovipositor of a horntail and realized the hardness of the wood into which it is forced, one soon concludes that this is indeed an accomplishment.

The tunnel enters vertically or at only a slight angle and measurements of tunnel depths by Chrystal (1928) ranged from 8-20 millimeters. It appears that females will occasionally bore "exploratory tunnels" in which no eggs are deposited. When eggs are deposited in a tunnel, the first egg is laid near the bottom, the ovipositor withdrawn a short distance and a second egg laid. This process is repeated until the oviposition tunnel contains three to four eggs commonly but often as many as six or seven (Chrystal, 1928). A single drilling operation and deposition of eggs takes 6-9 minutes (Lintner, 1899; Chrystal, 1928). There are usually several drillings made in each site. While it is generally assumed that the eggs are laid in the outer wood, Blackman and Stage (1918) reported the eggs of *Urocerus albicornis* Fabr. to be laid in the bark.

At the time of oviposition, the female introduces into the tunnel, fungus spores (Buchner, 1928; Francke-Grosman, 1939 in Benson, 1943; Chamberlin, 1949) which begin to grow prior to the hatching of the eggs. The growing fungi apparently produce an enzyme which acts upon the wood to make it digestible to the newly hatched larvae. Buchner (1928, cited in Chrystal, 1928) found that these symbiotic fungi of the genus *Oidia* were contained in two pear-shaped glands at the base of the ovipositor. He also demonstrated that these fungi were conveyed down the egg-tube at the time of oviposition and deposited within the oviposition tunnel. Chrystal (1928) confirmed these findings. Since these fungi are symbiotic, the wood attacked must be in a condition to support their growth. Only species belonging to the genus *Xeris* of the Siricinae have been recorded as not being associated with these fungi (Francke-Grosman, 1939 in Benson, 1943).

Horntail females are frequently found with their ovipositors firmly fastened in the tree. Being unable to withdraw, the adults have died in this position. Chrystal (1928) cites two reasons for this imprisonment. First, the female may have selected a tree in which the sap flow was too strong or one in which the wood was too wet. Under these conditions, the wood fibers closed tightly upon the ovipositor and would not give

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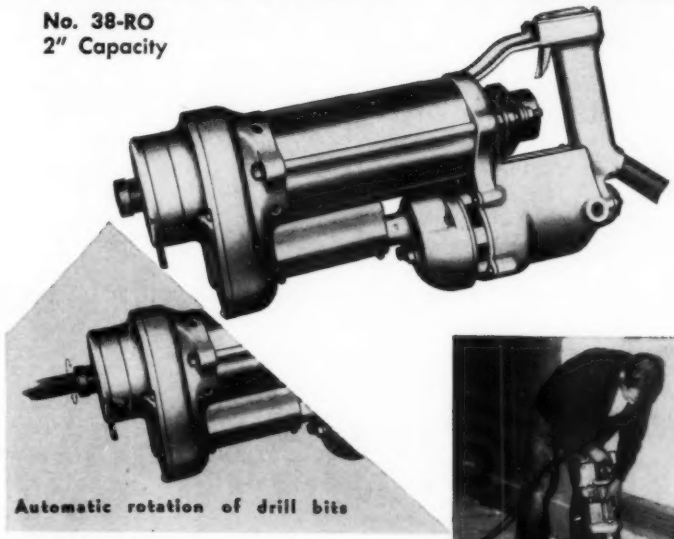

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sufficiently to allow withdrawal. Secondly, the female may have been near the end of her life span and had simply died in this position. A third reason which seems to be operative in Indiana and the middlewest region is the rather abrupt cold weather of the fall. In October of 1950, I saw over 20 dead females of the pigeon tremex on a shagbark hickory where they had apparently been stupified and killed by the first freeze of the year.

Eggs

The eggs of the pigeon tremex, *T. columba* were described by Harris (1862) to be oblong, oval, pointed at each end, and rather less than one-twentieth of an inch in length. Chrystal (1928) described the eggs of the blue horntail *S. cyaneus* and that of *Urocerus gigas* L. as being fusiform, constricted at one end and broadly rounded at the other, and measuring from 1.25 - 1.50 millimeters in length.

Records cited by Chrystal (1928) indicate a wide range in the egg-laying potential of various species. The egg-laying capacities for several species, based upon dissections of females, are as follows: *Urocerus augur* L., average of over 1000 eggs per female; *Sirex noctilio* F., average of 400 eggs per female; *Sirex cyaneus* F., range of 300-400 eggs per female.

The incubation period is recorded (Chrystal, 1928; Chamberlin, 1949) as being from three to four weeks. Chrystal (1928) reported that on two occasions he had found eggs hatching in February indicating a much longer incubation period for eggs deposited at the end of the season.

Larvae

Upon hatching, the larvae begin tunneling at right angles to the oviposition tunnel and for the first part of their lives, tunnel within the sapwood. The average size of the newly - hatched larvae is about 1.25 mm. When the larva has attained a length of 8-9 mm., it begins to tunnel inwardly and into the heartwood. After feeding for a length of time in this region, the larva turns outward and tunnels back into the sapwood. Thus, the typical larval burrow is roughly C-shaped and averages, in *S. cyaneus*, 10-12 inches in length.

The tunnels of *S. juvencus* are recorded as being 24-30 inches in length (Chrystal, 1928). In one heavily infested tree, burrows of many larvae were found which completely intersected one another for a distance of 20 feet (Johnson, 1928).

As the larva tunnels through the wood, the tunnel behind is packed tightly with frass and the cast larval skins. It is believed that the anal spine is used in packing this material as well as being used to support the larva in the tunnel. The number of larval instars is not known but Chrystal (1928) reported finding the first larval skins within the oviposition tunnel and that the first 3-4 molts took place at intervals of 1.8 mm. between each. Chrystal (1928) calculated the length of the larval period of *S. cyaneus* to be about 21 months

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out of a two year life cycle. In species having one generation per year, the larval stage would be approximately 9-10 months.

Pupae

Pupation takes place in the end of the larval burrow which terminates at various depths below the surface of the wood. Chamberlin (1949) stated that the pupae were found about one-half inch below the surface. The pupae of males are found nearer to the surface than are those of the females (Chrystal, 1928). If the insect pupates at too great a depth, and this happens very often, the adult is unable to chew its way out and dies within the burrow.

The larval burrow usually is made in such a way that the larva is oriented facing directly outward toward the surface of the wood or obliquely facing outward. This enables the adult to be so oriented that it can chew its way out in the easiest manner and over the shortest distance. However, upon occasion, the pupal site is parallel to the wood surface; thus, the adult must cut at nearly a right angle in order to emerge. This would indicate a remarkable amount of flexibility of body of the adult (Chrystal, 1928).

When feeding has ceased, the larva spins a cocoon made of silk and interwoven with wood chips (Harris, 1862; Lintner, 1899; Chrystal, 1928). The larva transforms into the pupa within this cocoon and remains in this stage approximately six weeks (Chrystal, 1928).

Upon becoming an adult insect, the horntail must now chew away nearly an inch of wood and bark in order to escape from the pupal site. There are records of adults that have not only bored through the wood but through wall panels, a bolt of cloth (Levick, 1926 in Chamberlin, 1949) and through overcoverings of lead sheeting, some of considerable thickness (Chrystal, 1928). The size of the emergence holes is about the diameter of an ordinary lead pencil.

Economic Importance
Injury to Forest Trees

It is generally believed that healthy, vigorous trees are rarely attacked by horntails except under atypical conditions. A notable exception is the damage done to the pine, *Pinus radiata*, in New Zealand by the introduced species, *S. juvencus*. It has been emphasized by Chrystal (1928), however, that perhaps silvicultural practices employed in New Zealand were not, in reality, conducive to the production of healthy, vigorous trees.

Horntail attacks are usually directed against trees which have become weakened by other insects, diseases, wind, fire, maturity or numerous other causes. Since these trees might otherwise be fit for cutting and the source of lumber, these insects then do pose a problem. Diseased American elms in the Lafayette area are a favorite host of the pigeon tremex and one can predict the approaching death of an elm by observing horntails ovipositing in the trunk. These attacks ordinarily occur before the disease is

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Aside from the injury caused to trees and the lumber which is cut from these infested sources, horntails have been observed to oviposit in sawed lumber.

Linter (1899) gives an account of a female of *Urocerus albicornis* ovipositing in freshly sawed spruce lumber at Carthage, New York. Blackburn and Stage (1918) recorded the same species hovering over spruce logs which had been stripped for pulpwood and were being piled on a skidway. Essig (1958) reported *Sirex areolatus* attacking cured redwood in California. Chamberlin (1949) wrote that *S. cyaneus* was found boring in wooden tanks at Powell River, B. C. Harris (1862) stated that adults had emerged from timbers which had been used in structures by carpenters. He also reported the emergence of several specimens of *S. gigas* from the floor of a nursery in a home in England. Bradley (1913) reported a similar incident as occurring in a house which was three years old. Chrystal (1928) reported that many records had been compiled of horntails emerging from furniture. Tragardh (1938), in Sweden, classified horntails as "accidental intruders . . . unable to breed in buildings." That author found the species to be more common in houses than in the forest.

Control

Forest and Shade Trees

There is no practical control of these insects in forest areas and, in fact, there seems to be very little need for it. Horntails have several interesting and equally spectacular parasites and it would probably involve this biological control approach should one be found necessary. Shade trees which are kept in a healthy condition are ordinarily not subject to attack. Should attack occur, it is probably secondary and indicates a weakened tree and a more serious primary cause.

Timber and Unfinished Lumber

Tree selection. The utilization of damaged or old trees for lumber increases the possibility of horntail infestation. If such trees are used, they should be water treated or the lumber kiln dried and cut into the largest size dimensions possible. The smaller the structural timber, the more weakened it will be as a result of larval tunnels.

Prompt Utilization or Proper Protection

Trees which are suddenly damaged or are judged to be mature should be promptly utilized. Removal of such trees will reduce subsequent horntail injury. Freshly-sawed lumber should be covered or properly attended if horntails pose a problem in the area.

Water Treatment of Logs. Logs containing horntails can be placed in a millpond and turned periodically as one means of control.

Kiln Drying. Most builders specify that the lumber will be kiln dried. It is obvious that these specifications are not being complied with because this process will kill all insects within the lumber. Not only are horntails emerging from timbers but we have received several beetles of the families Buprestidae and Cerambycidae which could not have sur-

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vived the kiln drying. There is always the possibility, however, that this drying may have taken place at an earlier date with subsequent storage under very moist conditions, which would allow for a post-drying infestation.

Emergence in Homes

The emergence of horntails in a home has several immediate effects. The first of these is the element of surprise and fear of seeing such large and somewhat vicious-appearing insects. It is difficult to convince a housewife that these insects will neither bite nor sting. The second effect is brought on because these emergences usually occur in new houses, most of them less than three years old. The third is the difficulty of explaining that these insects will not reinfest the house.

Since there is no way of detecting these infested timbers until the adults have emerged, there are no preventive control measures that can be used. After emergence, there is no need to control the insect although capturing the individuals and disposing of them is a good way to promote confidence and good will.

Because one infested timber may harbor many individual horntails, or there may be several such timbers, an inspection is certainly necessary to determine the amount of larval damage in each timber. It is possible that these timbers will need to be replaced. If the actual boring damage is not significant, the introduction of a good fungicide and perhaps a residual insecticide at the same time will prevent secondary invasions by fungi or other insects.

It is of importance to remember that the insects will not reinfest the house but that there may be several different emergences over a period of time as a result of several different infestations or because of environmental conditions associated with the various infested timbers.

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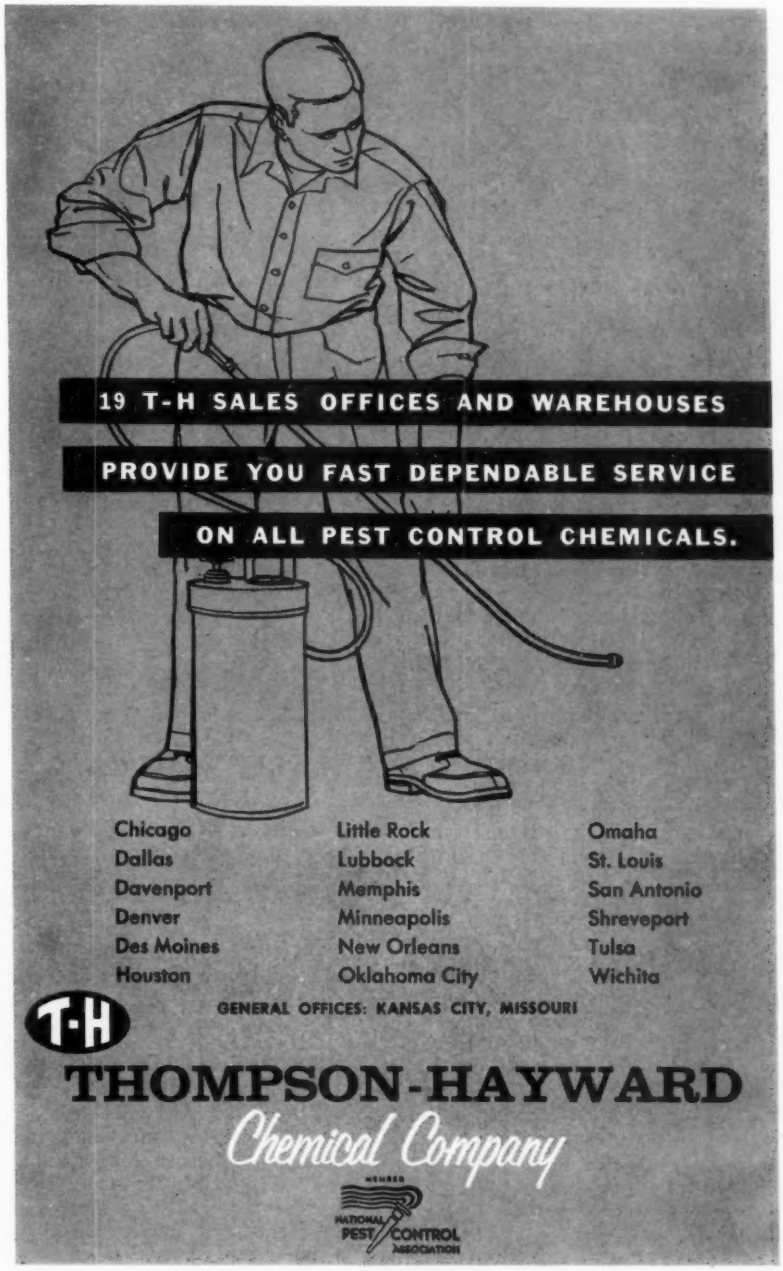

Higher Prices for Better Service Is Major Answer to Resistance

Resistant roach control is no longer only a battle with the bugs. It's become a battle with the books as well, a battle in which many PCOs try to reconcile increased service costs with an outdated pricing structure. The whole pattern of roach control has changed, and the operator must adjust to it or lose money. This is the general attitude of industry members, PC found last month.

"The methods and chemicals we use today are very different from ones used 15 years ago, and the methods and chemicals 15 years from now will probably be totally different from those of today," one Midwest PCO remarked. "This change takes place so slowly we do not realize it's happening. But it is, and we must raise our prices to meet it."

A West Coast operator compared today's low-price PCO to a car dealer who sells a 1959 runabout at 1939 prices. Regardless of the business you're in—cars or pest control—inflation is driving your material and labor costs up so you must hike prices. This is basic economics.

The straight, once-a-month service call for roaches is a thing of the past on most yearly contracts. In Florida, service on many roach accounts is now on a once-a-week basis. Even some northern PCOs have had to shift to regular, two-week servicing. And if roaches become resistant to organic phosphates, what then?

It's grim, but the more progressive companies are doing something about it. They are either raising prices $1-$2 or more on each account to take care of callbacks, or they are charging directly for callbacks. The important thing operators agree on—don't wait until you're nearly bankrupt before upping prices. It'll be too late. Make the change early.

"The resistant roach does not hit all types of customers at the same time," according to F. S. Kirkpatrick, Western Exterminating Co., Inc., Newark, N. J. "In the early years, trouble crops up first in taverns, restaurants, and apartment houses. Later on, bottling plants, grocery stores, and food manufacturing plants become seriously troubled. Finally, resistance shows up in office buildings and private homes. In the early stages of resistance, the PCO's experience with resistant roaches will be strongly affected by the nature of his business. Later on, it won't make much difference where his work is done."

Kirkpatrick stresses the only way to combat resistance is through better service, and this must be paid for. He cited statistics compiled during a mass meeting of PCOs in New York late last year:

"In the first year after resistance shows up, only 22% of us say our work is up to the standard we achieved before resistance. In the second year, things aren't much better, and 25% report results as good as ever; in the third year 40% have gotten their work up to par, and in the fourth year 50% say they are as good as before. By the fifth year, the remaining 50% say their control is almost as good as ever."

This means, Kirkpatrick emphasized, that customers won't tolerate poor results, and that there is no market for ineffective control when resistance suddenly pops up.

Service Increases Not Drastic

"In discussing the matter with those who have lived with the problem, it seems likely a small percentage of jobs will have to get two, three or four times the service given before resistance," he added. "But for the most part, reasonable service increases will suffice. In all probability, you will find you need more servicemen than you needed two or three years ago."

Material and Labor Costs Rise

Because of the industry's lack of a uniform accounting system, it's impossible to estimate how much a PCO's costs will climb throughout the industry. Some will report slight increases; others, large ones. Kirkpatrick said industry labor costs under resistance have risen between 15%-25%, and materials are up 20% to 35%.

John K. Medoff, Hudson Exterminating Co., Inc., West New York, N. J., cited other industry figures that bring the problem into sharp focus.

"In 1955 for every 100 man-hours of service work, a company spent an additional 5.7 hours on complaints," Medoff said. "Under resistant roach conditions, complaints will constitute 12.5 hours for every 100 man-hours of service work. This brings the efficiency of route operation to 87.5%.

"And since 1933, our wages have increased 500%, the official wholesale price index is up 300%, yet our prices have gone up only 100%."

How to Raise Prices

Because of the increased probability of infestation by resistant roaches, prices must be raised, and raised in proportion to the size of the structure, according to Medoff.

"If you have any doubts about raising an account, what ever you do, don't say 'no' for your customer before you even approach him," Medoff advised. "It's the customer's privilege to say 'no.' And you must never 'ask' for a raise. Simply tell the customer that the new price will be so much or that the increase will be so much. The word 'or' is important. Those of us who succeeded in adjusting our prices feel it is a mistake to do the arithmetic for the customer. Therefore, indicate the amount of the adjustment, or the amount of the new charge—not both."

Obviously, some customers will rebel against price in-

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creases. But if you are to give the customer good service, you must make adjustments. And if you give the customer a cut-rate price, plus the cut-rate service that must go with it, he'll be dissatisfied and probably start looking around for another PCO anyway.

"You'll seldom lose an account on price alone," Vernon Walter of Pest Control Services, Inc., Indianapolis, Ind., said. "There will usually be service problems or maybe personality problems. People are generally suspicious of a low price. If you don't do a consistently good job for your customer, someone else soon will."

John Gedeon of Knox Pest Control, Cleveland, O., started raising prices $1-$2 on each of his accounts two years ago. This was at the rate of 20%-25% of his accounts each month ("I didn't want to lose my whole business in one day," cracked Gedeon). Out of 900 accounts which he raised prices on, he lost only 42, and all 42 were the bottom-priced, $4 accounts. Net result upped his monthly income about $600.

A Charge for Callbacks

But Gedeon has gone one step further. On certain accounts where he is frequently called back to re-treat, he now charges for a regular service call. Without such a cost to the customer, accounts not requiring callbacks have to share the expense of such bonus service given to other customers. Then again, this extra charge for callbacks discourages the neurotic customer who likes to think he sees roaches when actually he doesn't. That's why one Texas PCO suggests at least a token $1 service fee for callbacks: "If the customer knows he's going to be charged for the callback—no matter how small the charge—he won't be telephoning you all the time."

Callbacks, Gedeon warns, are just too expensive not to charge for.

"Not only is the serviceman doing the work without bringing in any income," Gedeon said, "but he is also neglecting or putting off another customer on his route who would be paying for the service. So you lose two ways. Also, when you go back on the second trip, you usually have to spend more time than you did on the first call, since you have to find the roaches and satisfy the customer so he won't call you back a third time.

"If this resistance trend continues, and there's no reason why it shouldn't get worse, we're in trouble, since the bulk of our business is the $6 account, and if we service these accounts twice a month, we are getting only $3 a call. At $3 a trip, you cannot pay a man a decent living wage, furnish him with a truck, uniform, equipment, and chemicals; buy insurance; and pay office rent and office help, and still expect a profit."

All operators agreed that the only real obstacle that discourages many PCOs from raising prices is the fear that customers will flock to competitors. For that reason, it was recommended PCOs hold meetings with their competitors to discuss such matters openly.

But before the PCO can explain the economics of resistance to a customer, he has to learn them himself. In many cases, this is the biggest problem operators have yet to hurdle.

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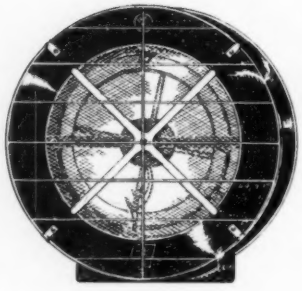

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GET SET FOR FLY CONTROL PROBLEMS . . . use HOPKINS MALATHION, DIAZINON or KORLAN 24E.

They give long lasting residual, maximum killing power and are safe for humans to handle. They're safe for you but deadly to flies—EVEN THOSE RESISTANT TO DDT, LINDANE, OR METHOXYCHLOR.

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AEROGEL
POWDER

DRIES ALL ROACHES TO DEATH

DO YOU HAVE A PROBLEM WITH HIGHLY TOXIC ROACH POISONS?

Silica Aerogel plus non-toxic, fast acting knockdown agents has been tried and proven in the field in actual tests and found to be the answer to the German food roach as well as complete control of all roaches.

Knockdown in 15 minutes and complete kill in one to two hours. Residual action lasts up to two months. Due to the fine particle size, Holiday Aerogel Powder will go four times as far as ordinary powders.

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SQUEEZE DUSTER CAN, 1¾ oz. retails $1.00 ea.
DEALER'S PRICE, Packed 1 doz. to case $7.20 doz.

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30 LBS.....$1.05 LB.
60 LBS..... .95 LB.
IN FIBRE DRUMS—FREIGHT PREPAID

WRITE TODAY FOR COMPLETE DETAILS AND FREE BROCHURE

PET CHEMICALS, INC.
1036 N.W. 21st TERRACE, MIAMI 42, FLA.

What's NEWS In The Industry

South Carolina PCA Attacks County PCO Bills As Discriminatory, Monopolistic, Unconstitutional

A wave of county-wide pest control bills introduced in South Carolina has led to one of the hottest legislation battles in years for the South Carolina Pest Control Association.

Seven bills with essentially the same wording have been introduced into the State Legislature. Six of these have been held up in legislative channels — mostly in the Senate Judiciary Committee. One bill did slither past the Senate, but was vetoed by Governor E. F. Hollings.

"These bills are discriminatory in nature, since they practically prohibit operators outside any given county from doing business in that county," B. S. Westall, South Carolina Terminix Co., Columbia, told PC last month. Westall is secretary of the SCPCA.

"Such laws," Westall continued, "also could be monopoly-creating in that licenses could be refused to all non-residents, and the local resident who is licensed could charge any fee he wished for even a small service. And finally, the Association believes them unconstitutional because all state operators would fail to receive just and fair consideration."

Westall admits South Carolina has its share of itinerant, fly-by-night operators. But county-level legislation is not the answer, he insists.

"Any legislation in South Carolina should be state-wide in scope, state-financed, state operated, and state-enforced," he said.

In one sample bill proposed for Marion County, all PCOs working in the county were to be licensed annually by the Board of County Commissioners. Violators would be subject to a fine of not more than $500 or imprisonment for not more than three months.

To combat the fly-by-nighter and eliminate the need for such county or state laws, the SCPCA has launched an intensive educational campaign.

"We are picking up friends right and left in the State Legislature," according to SCPCA president, E. M. Delk, Superior Termite Control Co., Charleston. "Members of these great bodies know the Association is attempting to see to it that the public does not suffer from unethical operators. Attorneys, mayors, solicitors of counties, and businessmen in general throughout the state are lending the Association great support."

Delk said several cases of suspected fraud were brought to the attention of the Association, and two well qualified, impartial inspectors from different companies checked the properties in question, then reported back to the Association.

"Convictions obtained this way will greatly strengthen our Association and place all honest members on a higher professional level," Delk concluded.

The North West Pest Control Conference drew 95 PCOs, sanitarians, and public health inspectors to Minneapolis, Minn.'s Raddison Hotel recently for a program covering rodent control, new insecticides, wood infesting insects, food plant sanitation, Food and Drug Administration laws, and mosquito control. Shown above during an intermission are, l-r, Ernest Levy, Radium Brand Pest Control Service Co., Minneapolis, president of the North West PCA; William O'Reilly, Plunket Exterminating Co., Minneapolis, NPCA regional vice president; Dr. Ralph Heal, NPCA executive secretary; Edwin Barck, Gopher State Exterminating Co., Minneapolis, NPCA regional director and vice president of the North West PCA; and Robert R. Laughlin, Smith Exterminating Co., St. Paul, Minn., secretary-treasurer of the North West PCA. The conference was sponsored by the North West PCA, with assistance from NPCA and University of Minnesota.

Trukil, Aldiel: Southern PCOs' Answers to "Orkil"

After the extensive Orkin Exterminating Company advertising campaign started in the South a few months ago to promote Orkin's new soil poison, "Orkil," it was only a matter of time before competitors would announce the development of their own termite chemical combinations.

Two new entries in the field are Trukil and Aldiel. Each is said to contain the "long lasting residual toxicity of dieldrin with the quick-killing action of aldrin." Orkil reportedly combines chlordane and heptachlor (PC, April '59, pg. 50).

Trukil is named after its developer, Truman Thomas, entomologist-owner of the Anti-Pest Company in Shreveport, La. Aldiel is the natural word combination of the two chemicals, aldrin and dieldrin.

Neither of the two new candidates for consumer acceptance have had as much advertising promotion as Orkil, but all three are termite toxicant combinations that claim long lasting effectiveness as soil poisons.

Bunn New AMCA Director

Col. R. W. Bunn, Bethesda, Md., has been elected regional director for the Southeast Central District of the American Mosquito Control Association. He replaces Dr. W. E. Bickley, who was chosen to be the association's vice president.

Use **MGK's** *Tested*

WATER SOLUBLE

Dipterex Powder*

To Positively Control Resistant German Roaches

NO OBJECTIONABLE ODORS

MGK DIPTEREX is the complete answer for the control of resistant and non-resistant German roaches in restaurants, bakeries, food shops and the many other places where unusual odors could cause a loss of business volume. DIPTEREX is both efficient and effective and creates no objectionable odors.

EXCELLENT RESIDUAL CONTROL

In addition to its positive effectiveness, DIPTEREX provides excellent residual control. Professional pest control users report up to twenty-one days control with from 90 to 95% improvement at the end of that period.

COMPLETELY WATER SOLUBLE

Being completely water soluble, DIPTEREX is not only economical, but eliminates the element of residual stains. If you are not using DIPTEREX, or do not have full information on its special properties, please send the coupon.

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Minneapolis, Minnesota

● Please send me a free sample of DIPTEREX, price and data sheet.

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ADDRESS_____

CITY_____ ZONE____ STATE_____

AMCA May Enter General Vector Field, Hess Says

"Our surveys would strongly indicate that a majority of the membership would favor expansion . . . into the general field of vector control." So stated Dr. A. D. Hess, new president of the American Mosquito Control Association.

Dr. Hess, who is with the U. S. Public Health Service in Greeley, Colo., also proposed the association might likewise change its name to the "American Vector Control Association" or "American Mosquito and Vector Control Association."

He said, "There exists a very real need for a professional association for individuals interested in the broad field of biology and control of arthropods of public health importance. We would emphasize that this includes mosquitoes and other species which may not be vectors of specific diseases, but which through blood-sucking or other annoying habits interfere with man's physical and mental well being."

A questionnaire was sent to 161 mosquito abatement agencies located throughout the United States and 81% of the respondents stated that mosquito abatement agencies should be engaged in other vector control activities in addition to mosquito elimination. Biting and non-biting flies; fleas, ticks, mites, and chiggers; household pests and "all arthropods of public health importance" were among the "other" vectors MAD officials felt should be included.

President Hess proposed action be taken during the coming year to determine if the majority of the AMCA membership favors expanding the scope of the association's activities.

Premiere Pyrethrum Film

"The Pyrethrum Story," a new 16mm, color, sound motion picture filmed in the pyrethrum growing areas of the Equatorial Highlands in British East Africa and the Belgian Congo, was premiered in New York last month.

Twenty-two minutes long, the film shows how pyrethrum flowers are harvested by hand, dried, compressed, screened, and finally transformed into a viscous liquid which provides the base for pyrethrum insecticides. Also included in the film are scenes of the African countryside, wildlife, and natives.

Sponsors of the film, the African pyrethrum growers, have made "The Pyrethrum Story" available to TV stations, colleges, and adult groups without cost. To arrange for showings, write Tribune Films, Inc., 141 East 44th St., New York 17, N. Y.

The 42 industry members at Pennsylvania State University's PCO Short Course recently heard talks from Dr. Philip Spear, technical director of the National Pest Control Association; Professor Howard Higbee and Charles Guenther, of Penn State; Earl K. Seybert, Davison Chemical Div., Baltimore, Md.; Arnold Mallis, Gulf Research and Development Co., Pittsburgh; and Mrs. Jeanne Held, Bell Telephone Co.

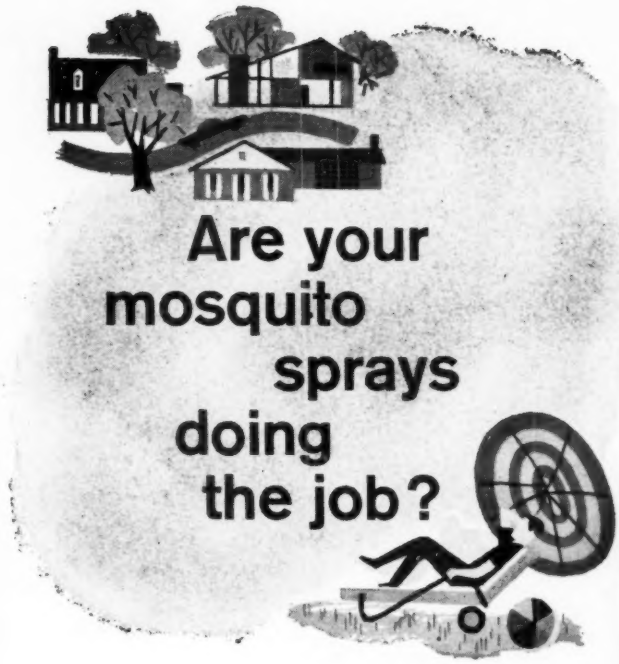
Sees No HCN Residue Hazard

Although hydrogen cyanide is a rapidly acting acute poison, it "is of no hazard in the amounts incurred as residues in foods fumigated with HCN," according to the Food and Drug Administration's Dr. Arnold J. Lehman.

Writing in the Quarterly Bulletin of the Association of Food and Drug Officials of the U. S., Dr. Lehman said HCN is a highly toxic compound with a fatal oral dose for a man of 50 to 90 mg. or about 1 mg./kg. In the bodies of higher animals it is rapidly converted to the far less toxic thiocyanate. This rapid conversion of the toxic material to a much less poisonous compound is the basis for his opinion that the hazard from HCN residues in food is of slight consequence.

Dr. Lehman's report, "Hydrogen Cyanide and Amygdalin," appeared in the Association's Quarterly Bulletin 23(1):55-58, 1959.

Complete ground-to-air pest control is now offered by Canada's PCO Services, Ltd., Toronto, Ontario. Working with PCO Services is Roy Twinn, who operates an aerial pest control service. Twinn and Alfred H. Gartner, PCO Services' Assistant General Service Manager in charge of all co-ordinated ground and air operations, are available to customers as consultants. This service includes making surveys and preparing aerial and ground programs.



Each year more and more cities and resort areas depend on LETHANE 384 for mosquito control. When used for fogging and adulticiding applications the remarkable knockdown and kill counts obtained even on resistant varieties pleases officials, pleasure-seekers, operators and tax payers.

Ask your custom sprayer or your local pesticide dealer about LETHANE 384 . . . or write directly to our Agricultural and Sanitary Chemicals Department for complete information.

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UNI-VAP VAPORIZER

Sells Better
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Every unit backed by 8 years of successful sales, unmatched performance. Competitive price and long margin produces maximum profit for you. Quality construction and dependable performance assure complete customer satisfaction. See and test the Uni-Vap before you buy.

UNIVERSAL ORTHO-LINDANE
Fresher for higher potency
Better kill in any vaporizer
1 oz. heat sealed, leakproof packets
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Write for new lower prices and literature.

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The ORB BOMB contains a high potency non-toxic formula made especially for commercial and industrial use. Only 2 seconds is needed to treat 1,000 cu. ft. of space for flies. Controlled spray rate prevents waste. Fine particle size eliminates spotting. For use in control of houseflies and fruit flies. May also be used in controlling resistant roaches in areas where a non-toxic spray must be used. In ¾, 1¼ and 3 lb. sizes.

OTHER AEROSOL PRODUCTS

#102	Aerosol Deodorant
#103	Aerosol Mothproofer
#106	Aerosol Insecticide
#107	Roach and Ant Bomb
#104	Moth Control

All Aerosol Products with Your Private Label at Minimum Printing Charge.

Write Us For Prices And Details

ORB INDUSTRIES **Wallingford Rd. Springfield, Pa.**

Publications for PCOs

Here are the latest government, university and association publications of interest to pest control operators. Some can be obtained free of charge, while others are nominally priced. When ordering, include title and catalog number, if any. Sources follow booklet titles.

Bats, Public Health Importance and Control. 1958. 3p. Training Branch, Communicable Disease Center, 50 Seventh St., N.E., Atlanta 23, Ga.

Clover Mites, How to Control Them Around the Home. Catalog No. A 1.35:443. 1958. 6p. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 5c.

Controlling Insects and Diseases on Ornamental Trees. 1958. 40p. Bulletin Office, Michigan State University, Box 231, East Lansing, Mich.

Controlling Rats and Mice in Iowa. Pm252. 1959. 4p. Publications Distribution Room, Morrill Hall, Iowa State College, Ames, Ia.

Insects and Mites Associated with Stored Foods and Seed in California. Bulletin 47 (3): 233-249. 1958. 17p. California State Printing Office, Sacramento, Calif.

Insects That Carry Disease. Catalog No. FS 2.50:90. 11p. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 10c.

Magpie Control in Alberta (Canada). Publication No. 120. 1958. 6p. Extension Service, Alberta Department of Agriculture, Edmonton, Alberta, Canada.

Moisture - Barrier Performance of Ground Covers in Basementless Homes. Forest Research Notes, No. 85. 1958. Northeastern Forest Experiment Station, Upper Darby, Pa.

Pigeons, Their Public Health Importance and Control. 1959. 3p. Training Branch, Communicable Disease Center, 50 Seventh St., N.E., Atlanta 23, Ga.

Geigy's Dr. Alexander Killed

Dr. C. C. Alexander, director of research, Agricultural Chemicals Division, Geigy Agricultural Chemicals Corp., Ardsley, N. Y., was one of the victims of a Capital Air Line plane explosion over Baltimore May 12.

The 46-year-old past president of the Eastern Division of the Entomological Society of America had been associated with Geigy 14 years. He received his BS degree from Purdue University and his MA degree from Iowa State College.

Purdue Wants Termites

The Department of Entomology at Purdue University has requested the cooperation of PCOs in obtaining termites for the department's collection. Reproductives and/or soldiers are especially desired, and workers may be included. However, collections of workers without the other castes are not wanted.

Before sending specimens to Purdue, preserve them in 70% alcohol (rubbing alcohol). Then package them in a small rigid box and send to Dr. John V. Osmun, Head, Department of Entomology, Purdue University, Lafayette, Ind., and include date specimens were collected, locality where they were collected, situation in which the termites were encountered, and name of the collector.

Wisc. Sanitarians Pick Roberts

Kenneth E. Roberts, director of sanitation for Wil-Kil Pest Control, Milwaukee, Wisc., was elected president of the Wisconsin Association of Sanitarians at a recent meeting and seminar at Port Edwards.

THE FAVORITE WITH PCOs

IDICO STAR
Pistol-Type
SPRAYER

Save money by using a sprayer that delivers small amounts of expensive chemicals direct to infested areas without dripping, flooding or waste.

Designed for Pest Control work: Insecticides, Deodorants; Disinfectants, etc.
It is light . . . compact, has a new easy hand grip control — no dripping, easy to fill.

HAS TWO (2) INTERCHANGEABLE NOZZLES:
1 - Fine Fog Spray
2 - Penetrating Pin Stream (reaches 20 feet)
B1 - One Quart Container (brass bottom) - straight extension - $10.50.
. . . on orders of 6 or more units 10% discount . . . all copper container, add $1.25 to price, — Your Best Buy!

IDICO PRODUCTS CO.
18 W. 125th St., New York 27, N. Y.

Please send us _____ units
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There's **NO SUBSTITUTE** for
44 Years' Experience!

Pest Control INSURANCE

Every phase of Rodenticide and Insecticide Coverage for Pest Control Operator And Allied Industries

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- **Public Liability (1080 included)**
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Notebook

TIPS AND IDEAS FROM THE FIELD

Places You Can Skip On Monthly Roach Jobs

by Vernon E. Walter
Pest Control Services, Inc.
Indianapolis, Indiana

With today's industry pricing structure what it is, no PCO can afford to give clean-out service each and every month on routine contracts. Yet, if he is to combat resistant roaches effectively, he must do a thorough job. Because of these conflicting conditions, the operator must know what areas can be skipped on regular calls, what areas must be treated.

In our company, we hold meetings from time to time to discuss typical accounts most of the servicemen know. We cite actual samples of places that can be skipped. This alerts servicemen to typical trouble spots that need regular treatment, plus those in which there is less likelihood of infestation. It also drives home the need for time economy.

For instance, there is no sense in spraying ceramic quarter-rounds where there is no crack, and around rooms in exposed areas where the chemical would be frequently washed away. Modern chemicals do not have sufficient residual to kill insects that merely crawl across them. We must get the insecticide into cracks or other areas where roaches rest.

The dining room in restaurants is another place that is often unnecessarily treated. If you did a complete clean-out in the dining area when you took over the account and maintain it in good shape, chairs and tables should not be re-infested if proper sanitation measures have been followed. Nevertheless, the tables and chairs should be checked from time to time.

In grocery stores, check-out stands are usually not a problem. But your individual experience will have to determine whether they can be skipped or not.

Now, how often should these "skipped" areas be treated?—Probably about every other month, or even every third month. Dining rooms in restaurants should be treated at least twice a year.

These are only a few of the spots that can go untreated. But these suggestions should start you thinking. Meet with your servicemen to get their ideas. Remember, any PCO can control resistant roaches with thorough clean-out service every month, but this won't do him any good if he goes broke on the deal.

Real-Kill "Spectacular"

The largest consumer magazine double-page, four-color advertisement ever devoted to pest control chemicals appears this month in the Ladies Home Journal under the sponsorship of Real-Kill Co.

Bound into this spread, which the advertising trade calls a "spectacular," is a 12-page 5" x 6½" booklet, "Hints for Bug-Free Living," which includes drawings of major household insects, tells where they are commonly found, and how to control them with Real-Kill insecticides.

Copies of the little booklet may be obtained by writing Real-Kill Co., P. O. Box 78, Kansas City 41, Mo.

While designed to stimulate sale of Real-Kill products, public demand aroused by this unusual advertisement will increase the sale of all consumer-packaged pesticides.

MSU Conference

(from page 36)

ogy, Harry Sinclair, and Giles Isham.

In methyl bromide fumigations for insects that infest living products, such as seeds, grain, bulbs, onions, and other crops, Henry Grey of the Dow Chemical Co., Midland, Mich., stressed the importance of the relationship between temperature, exposure time, and chemical concentration. Failure to compensate for any one of these three factors, he warned, could result in injury to or killing of the commodity under fumigation.

A business session on the final day featured a talk on selling by Professor Paul Moore of MSU's Continuing Education Services; and another on insurance, by William Hunt of the Wolverine Insurance Co.

$275 Million for Insecticides

About $275 million worth of insecticides are now purchased annually, according to a recent survey.

POSITIVELY CONTROL
Resistant
BROWN DOG TICKS
AND FLEAS

AS-575
Emulsifiable Concentrate

ENTIRELY NEW CHEMICALS

Specially Developed as a Specific for Resistant Brown Dog Ticks

AS-575 positively kills and controls resistant Brown Dog Ticks . . . in lawns, yards, doghouses, other premises frequented by dogs—indoors and out.

This entirely new organic phosphate formulation, developed in the Agricultural Specialties laboratories, has been proven tremendously more effective than other organic phosphate preparations.

- BETTER CONTROL
- LOWER COST
- COMPLETE CUSTOMER SATISFACTION

Write for Complete Information

Developed and Manufactured by
AGRICULTURAL SPECIALTIES
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DALLAS * TEXAS

Calendar

(N. Y.) Professional Exterminators Assn. June Meeting, Museum of Natural History, New York City, June 8, 8 p.m.

Professional Pest Control Assn. of Dallas County June Meeting, El Chico Restaurant, Dallas, June 9, 7 p.m.

Washington (D.C.) Pest Control Assn. June Meeting, 4904 Wisconsin Ave., N.W., June 15, 8 p.m.

Arkansas Pest Control Assn., June Meeting, Brinkley, Ark., June 20, 10 a.m.

National Assn. of Sanitarians, 23rd Annual Educational Conference, Deauville Hotel, Miami Beach, Fla., June 22-26.

New York Pest Control Assn. 3rd Annual "Day in the Country," Pines Ridge Country Club, Pines Ridge, Ossining, N. Y., June 25, 9 a.m.

Texas Pest Control Assn. June Meeting, Student Center, Texas A & M College, Bryan, Tex., June 25.

Texas A & M College Short Course, Student Center, Texas A & M College, Bryan, Tex., June 25-26.

Florida Pest Control Assn. Annual Convention, Fort Harrison Hotel, Clearwater, June 25-27.

Georgia Pest Control Assn. Summer Meeting, General Oglethorpe Hotel, Savannah, June 26-28.

South Carolina Pest Control Assn. Summer Meeting, General Oglethorpe Hotel, Savannah, June 26-28.

North Carolina Pest Control Assn. Mid-Summer Meeting, Morehead-Biltmore Hotel, Morehead City, July 23-25.

Virginia State Pest Control Assn. Summer Meeting, Cavalier Hotel, Virginia Beach, August 21-23.

Eastern and Western Divisions, Pennsylvania Pest Control Assn. Joint Meeting, Allenberry Inn, Boiling Springs, Sept. 11.

Canadian Agricultural Chemicals Assn. 7th Annual Meeting and Conference, Chateau Frontenac, Quebec City, Sept. 20-23.

4th Annual Industrial and Building Sanitation-Maintenance Show and Conference, New York Trade Show Building and New Yorker Hotel, New York City, Sept. 22-24.

National Pest Control Assn. 26th Annual Convention and Trade Show, Buena Vista Beach Hotel, Biloxi, Miss., Oct. 18-22.

American Public Health Assn. Annual Meeting, Atlantic City, N.J., Oct. 19-23.

National Agricultural Chemicals Assn. 26th Annual Meeting, French Lick - Sheraton Hotel, French Lick, Ind., Oct. 21-23.

A new Hudson 7½-gallon power sprayer, called the Comando, features a positive piston pump, reportedly discharges any sprayable solution at the rate of 1½-gallons per minute. Pressure is adjustable and factory-set at 80 pounds. A mechanical agitator is said to keep the spray solution in the tank thoroughly mixed. Complete with 10 feet of Spray-Proof hose, rotatable control valve, and a 24-inch curved brass extension with a nozzle that adjusts to any spray pattern, the Comando sprayer is available in gas or electric models. For more information, write H. D. Hudson Manufacturing Co., 589 East Illinois Street, Chicago 11, Ill.

Offers Squeeze Can Aerogel

A silica aerogel insecticide that comes in a 1¾-ounce squeeze can for re-sale or use has been marketed by Pet Chemicals, Inc., 1036 N.W. 21st Terrace, Miami, Fla.

Called "Holiday Aerogel," the chemical is said to kill insects through a drying out action once it contacts their bodies.

According to Pet Chemicals, Holiday Aerogel has proven effective against confused flour beetles, red flour beetles, sawtoothed grain beetles, rice weevils, granary weevils, and larmoths; German, American, oriental, and brown-banded roaches; vinegar flies; house flies; honey ants; black carpet beetles; drywood termites; bedbugs; and cat and rodent fleas.

Reportedly non-toxic to both humans and animals, one can of Holiday Aerogel is enough to treat an average home for roaches, Pet Chemicals claims.

Omitted in Equipment Index

In PC's 1959 PCO Equipment Directory (May, pp. 26-51), Chapman Chemical Co. was inadvertently omitted from the list of industrial aerosol suppliers. Chapman's address is P. O. Box 138, Memphis 1, Tenn.

MARTINDALE

PROTECTIVE MASKS

ONLY **30c** each

PLACE HEADBAND WELL UP AROUND HEAD TO KEEP FROM SLIPPING DOWN

PRESS NOSE TABS IN CLOSE AGAINST FACE TO HOLD PAD AGAINST THE NOSTRILS

PRESS EDGES OF FACE PLATE DOWN TO FIT FACE SNUGLY

Refills 2c each

so comfortable! so easy to wear!

Amazingly easy to breathe through! Mask weighs less than ½ ounce complete. Adjustable to any head size. Replaceable throw-away filter pads — only clean gauze touches the face. Positively protects against over 400 nuisance dusts. Easily pay for themselves in added comfort, convenience, protection.

Protective Masks ..... **$.30 ea.**
No. 1 Refills (standard wt.) ..... **.02 ea.**
No. 2 Refills (double-thick pad) ..... **.02½ ea.**

Masks packed in individual envelopes. Refills packed 25 to a box. Minimum charge or C.O.D., $2.00. Minimum cash with order, $1.00. Postage paid on all cash orders.

QUANTITY DISCOUNTS AVAILABLE

MARTINDALE ELECTRIC CO.
1367 Hird Ave. Cleveland 7, O.

You Can **MAKE MORE MONEY**

by using and selling

FUMO-KILL

The New Effective Fumigant That Will Kill

Mosquitoes, Flying Moths, Spiders, Silverfish, Flies, Wasps, and Exposed Waterbugs, Roaches, Bedbugs, and Ants.

FUMO-KILL is truly the modern method of insect extermination. Light match to contents in can, will produce fumes — NO FLAME. Non-hazardous. This amazing FUMO-KILL insecticide has been tested, and found effective against most types of household pests.

FUMO-KILL has the following advantages:

EASY TO USE: Requires no Special Equipment.

ECONOMICAL TO USE: Two ounces fumigates up to 6,000 cubic feet.

EFFECTIVE TO USE — Follow instructions on can for best results. **This Amazing FUMO-KILL insecticide is by all qualifications, a leader in its field.**

FUMO-KILL can be obtained in 2 oz. (enough for up to 6,000 cubic feet)—4 oz. and 1-lb. cans.

Cost of 12—2-oz. Cans ... **$ 7.50 per doz.**
Cost of 12—4-oz. Cans ... **$13.50 per doz.**
Bulk ..... **$ 4.50 per lb.**

Delivery Charges Prepaid
For complete information write or phone today.

MAR-MEL PRODUCTS, INC.

Phone: Van Buren 6-2060-61

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TRIGGER *TeeJet*® **SHUT-OFF VALVES**

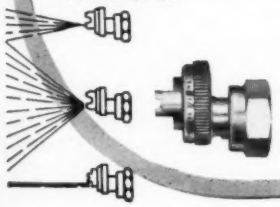
Light weight, balanced, snug hand-grip. Lock catch and positive shut-off.

Supplied with complete choice of tips, and connections.

pick the tools to fit the job

EXTENSIONS—Straight and curved extensions in choice of lengths from 8" to 48".

MULTEEJET TIPS—tip indexes to give medium and fine flat sprays...and medium and solid straight stream sprays.



ADJUSTABLE CONEJET TIPS

Tip rotates for spray selection from fine solid stream...to wide angle, finely atomized cone spray.

For information write for Bulletins 76 & 72.

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The Original . . .

And Still The Best!

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POWDER BLOWER

$1.25 EACH F.O.B. St. Louis, Mo.

Order Your Supply Today!

GETZ EXTERMINATORS, INC.

2234 OLIVE STREET **ST. LOUIS 3, MO.**

Infestation Report

Contains pertinent portions of the Department of Agriculture's **Cooperative Economic Insect Report**, material from university entomology departments and reports from readers. PCOs noticing infestations in their own areas are urged to communicate with **Pest Control** so their information may be added to this infestation report.

AMERICAN DOG TICK
(Dermacentor variabilis)

Delaware: First specimen of season collected from dog in New Castle County. **Oklahoma:** Appearing in annoying numbers in limited areas, Payne County. **Virginia:** Seed ticks, probably D. variabilis, numerous in vicinity of Holland, Nansemond County.

CARPET BEETLES

North Dakota: Home infestations of Anthrenus scrophulariae reported from McHenry and McKenzie Counties. **South Dakota:** Infestation of Attagenus piceus reported in a McPherson County home.

COCKROACHES

California: Light populations of Blattella vaga in decaying wood in Needles area, San Bernardino County. **Maryland:** Supella supellectilium heavy in a home in Baltimore. **New Mexico:** Blatta orientalis a problem in many buildings at Lovington, Lea County. **South Dakota:** S. supellectilium reported from a home in Grant County. **Utah:** B. orientalis present in homes at Provo and Pleasant Grove and numerous in a home at Murray.

IMPORTED FIRE ANT
(Solenopsis saevissima richteri)

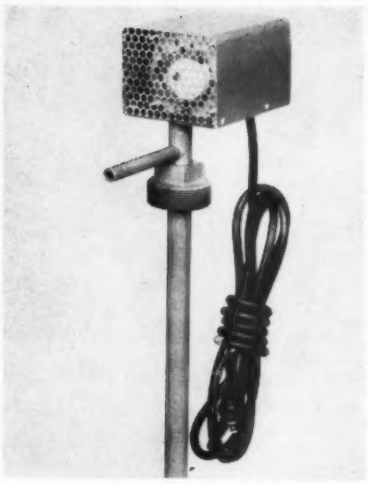
Arkansas: Few scattered mounds continue to be found in Union County, only known infested county in state. Individual mounds treated. **Florida:** Polk County infested for first time. **Georgia:** First infestation reported in Stewart and Terrell Counties.

POWDER POST BEETLES
(Lyctus spp.)

Nebraska: Damage to hardwoods in buildings more numerous than previous years. Majority of infestations in oak from out of state.

TERMITES

Georgia: Numerous reports of R. flavipes throughout state. **Idaho:** Winged males and females of R. hesperus emerged in Gooding area. **Maryland:** Winged forms of Reticulitermes flavipes in and around homes in Baltimore; and Ann Arundel and University Hills, Prince Georges County. **North Carolina:** Flights observed in a home and commercial building in Wake and Johnston Counties. **Pennsylvania:** Swarming in homes in Centre and Union Counties and other areas. **Utah:** Infesting homes at Pleasant Grove, Provo, and Logan. **Wyoming:** Reticulitermes spp. damaged at least two houses, 35-40 years old, in Riverton, Fremont County. Support studdings had been placed on soil and many are completely hollowed out.



"Enpo" Controlled Volume Drum Pump, manufactured by Piqua Machine and Manufacturing Co., Piqua, O., reportedly measures the flow of chemicals and other liquids to a solution automatically and in constant concentration. Designed for 15, 30, and 55 gallon drums, the "Enpo" Drum Pump operates automatically or manually and can be regulated for intermittent or continuous duty. The predetermined rate of flow is controlled by changing cams in the pump. All three sizes have rigged corrosion-proof teflon seals; are made in carbon steel for non-corrosive liquids and in stainless steel for corrosive liquids. They will deliver 10-12 gallons per hour to a 30 foot head, pumping liquids of varying viscosities from storage room directly to tank, according to Piqua.

CDC Films Local Vector Control

A new 16mm, color, sound motion picture entitled "Community Vector Control Demonstration Program" (M-283) is now available for short-term loan in the U. S. from the Communicable Disease Center, P. O. Box 185, Chamblee, Ga.

Aimed largely toward an audience of municipal and environmental sanitation personnel, the film shows how a community vector control program is organized and carried out, what legislation is necessary, and how to obtain community cooperation. Demonstration programs in four states are documented.

The film is 24 minutes long, has been cleared for television.

Tweezer-magnifying glass combination, made in Germany, is being distributed by Hub States Chemical & Equipment Co., 1255 N. Windsor St., Indianapolis, Ind. Pocket-size, the unit folds up, fits into a small leather carrying case. The fine tips of the tweezers, hinged to the magnifying glass handle to guarantee accurate positioning, are said to secure the insect directly below the 4-power lens for examination.

Suppliers' Staff Changes

Wade Brown of Charlotte, N. C. has been appointed Chapman Chemical Co. district sales manager for North Carolina, South Carolina, and parts of Tennessee and Georgia. Before joining Chapman, which has its headquarters in Memphis, Tenn., Brown was employed by R. T. Vanderbilt Co.

Hopkins Agricultural Chemical Co., Madison, Wisc., has announced the appointment of **Lynn K. Brunn** as technical service manager. Brunn was formerly with Atlas Powder Co.

S. B. Penick & Co., New York, N. Y. made seven personnel shifts recently as part of a realignment of its sales and service divisions. **Barclay E. Mackinnon,** formerly vice president of New York Quinine & Chemical Works, Inc., was named vice president in charge of the NYQ Chemical Div. **Harold A. Meyer,** vice president, is now in charge of the Botanical & Allied Products Division, with **William W. Bell,** vice president, as assistant manager in addition to his responsibilities for the division's domestic products and all cultivation projects. **Frank Seeland,** vice president, continues as manager of the newly named Farm Chemical & Insecticide Division, which has added antibiotic feed supplements to its line of products. **Rudy P. Neptun,** formerly vice president of New York Quinine & Chemical Works, Inc., is a new vice president with special responsibilities in sales development and promoton. **William A. Thawley,** former sales manager of New York Quinine & Chemical Works, Inc., is new director of sales coordination for Penick. **James J. Verde,** formerly assistant sales manager of New York Quinine & Chemical Works, Inc., has been appointed sales manager of the NYQ Chemical Division.

Paul L. Lonnecker has been appointed vice president and general sales manager of Thompson - Hayward Chemical Co., Kansas City, Mo., and **Ervin W. Segebrecht,** administrative assistant to the executive vice president and to the vice president - sales. Thompson-Hayward also has named **Dan N. Lilly** as Oklahoma City branch manager. His address is 3909 S. Meridian.

Two new sales representatives have been named by Geigy Agricultural Chemicals, division of Geigy Chemical Corp., Ardsley,

N. Y. They are **Wilbur C. Hanes** of Covina, Calif. and **Vernon E. Anderson,** Kansas City, Mo. Hanes will represent Geigy in the Southern California and Arizona areas; and Anderson, in Wyoming, Colorado, Nebraska, Kansas, and Missouri.

The appointment of **Bogardus Werth** to its chemical sales staff has been announced by Michigan Chemical Corp., Saint Louis, Mich. Werth's home is located in Savannah, Ga., from which he will service Michigan chemical customers in the southeast.

New assignments for three men in biochemicals sales have been announced by the Du Pont Grasselli Chemicals Department. In the Wilmington, Dela. home office, **Dr. Joseph A. Evans** has been named product manager, insecticides and fungicides; and **Dr. Burton B. Hodgden,** who has been a sales representative in Memphis, Tenn., comes to Wilmington to be sales promotion supervisor on these products. **Dr. Lyall F. Taylor** is transferred from a sales territory in California to Wilmington as sales promotion supervisor on herbicides.

U. D. Tidwell has been appointed North Alabama sales representative for uniform manufacturer, Riverside Manufacturing Co., Moultrie, Ga. Tidwell resides in Birmingham.

Neil A. Maclean Co., Belmont, Calif., has announced the appointment of **Floyd W. Hutchings** to its Seattle, Wash. office. Hutchings received his B.S. degree in entomology from the University of Washington, did graduate work at the University of California.

Canada's PCO Ltd. Names Two

PCO Services, Ltd., Toronto, Ontario, has announced two new appointments. Dr. Stanley N. Ward has been named head of the company's new Sanitation Consulting Division, and William Burr, a specialist in milling pest control for the last five years, has joined PCO Services' milling pest control division.

Dr. Ward has been prominent in the field of public health in Canada for the last 10 years. Before joining PCO Services Ltd., he was assistant director of food control and sanitation for the city of Toronto.

Primer

Serviceman Training Outline: 6

by Robert E. Berns
Aerosol Exterminators, Chicago, Illinois

LESSONS
Jan.: Introduction, Background
Feb.: Serviceman's Function
Mar.: What Is An Insect?
Apr.: Insecticides, Rodenticides
May: Rat & Mouse Control
✓ **Jun.:** Roaches & Their Control
Jul.: Bedbugs & Their Control
Aug.: Silverfish & Their Control
Sept.: Ants & Their Control
Oct.: Don't Be Half Safe!

As the problem of insect resistance mounts—particularly among roaches—the need for better skilled servicemen increases. Only the serviceman with a sound know-how of chemicals and control methods and equipment can lick resistance. This adds to the need for conscientious serviceman training. The idea behind PC's current 10-part series of outlines, based on a rugged, scientifically-developed training program used by the armed forces, was proved during the war when raw recruits without any combat experience were converted into a tough, effective fighting machine. Similar outlines are not only used by the Army now, but by reserve and National Guard units, as well. Why not by you? The pace of training depends upon the instructor. Maybe he can wrap it up in three weeks—perhaps he'll want to lengthen classes to three months or longer. But whether you skim lightly over the outlines, or go into them thoroughly, you'll develop in your new men the confidence that comes with sound training procedures. Like the Army, you won't be sending a man into combat without a rifle.

Roaches & Their Control

Scheduled For: (Date and Place)

References

Up-Date on Roach Control for the PCO. Pest Control, June 1958. Trade Magazines, Inc., 1900 Euclid Ave., Cleveland 15, O.

Destructive and Useful Insects, Metcalf, Flint, and Metcalf. 1951. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.

Handbook of Pest Control, Mallis. 1954. McNair-Dorland Co., 254 W. 31st St., New York 1, N. Y.

Materials

1. Drawings and photos of roaches
2. Blackboard, chalk

Object

To familiarize trainee with roaches and their control

Method

Discussion on biology and habits of roaches, procedures for control

Presentation

1. Five roaches encountered in our area—American, Oriental, German, Brown-banded, Pennsylvania Woods Roach
2. Life histories of common species to include egg, number of capsules, hatching time, nymphal life
3. American roach: nymphs and adults reddish brown; adults 1½ inches long with wings longer than abdomen. Habitat: areas with warm temperatures, such as steam tunnels, restaurants, bakeries. Near food.
4. Oriental roach: black or brownish black; adult males 1 inch long, narrow wings not quite covering abdomen; adult female 1-¼ inches long, heavy body, wing stubs only. Habitat: sewers; dark, damp basements
5. Brown banded roach: nymphs reddish brown with light cross bands; adults tan to dark reddish, indication of band across wings, ⅝ inch long. Habitat: in furniture, scattered throughout house
6. German roach: nymphs blackish with vertical lighter bands on thorax; adults tan, ½ to ⅝ inch long. Habitat: homes, restaurants, food stores, around food and dampness
7. Smoky Brown Roach: male and female adults dark brownish, slightly over an inch long, with wings longer than body; young nymphs have ends of abdomens curled up like rove beetles. Habitat: prefers high temperature and humidity; found in homes, greenhouses
8. First consideration in control—establish sanitation
9. Chemical control by organic phosphates where possible and pyrethrum-type sprays around food
10. Modern resistance — painstaking accuracy and thoroughness demanded

Demonstration

1. Simulated German Roach cleanout by foreman

Examination

1. Oral questions on biology of roaches
2. Oral questions on roach control measures

Fumigant Applicator Patented

A "Little Squirt Spot Fumigant Applicator" designed mainly for use in the cereal milling industry has been granted a U. S. Government patent, according to the manufacturer, Ferguson Fumigants, Inc., Ferguson, Mo. "Little Squirt" applicators were reportedly developed for measuring fumigant dosages of two ounces or less.

Classifieds

When answering ads where box number only is given, please address as follows: Box number, c/o Pest Control, 1900 Euclid Avenue, Cleveland 15, Ohio.

Rates: "Position Wanted" 5c per word, minimum $2.00. All other classifications, 10c per word, minimum $2.00. All classified ads must be received by Publisher the 10th of the month preceding publication date and be accompanied by cash or money order covering full payment.

HELP WANTED

OPPORTUNITIES UNLIMITED. The world's largest pest control organization (AAA-1 rated) has interesting openings for men with initiative and ambition. We operate in 28 states from coast to coast and there are opportunities open in many phases of our operation . . . servicemen, managers, technical representatives and salesmen. Experience in professions related to pest control helpful, though not necessary. Liberal salary and incentive arrangements provide unparalleled opportunities for men with good judgment and the ability to get along with people. Our firm, over 50 years old, offers employee benefits including paid vacations, sick leave, life insurance, hospitalization and pension plan. All replies confidential. Interviews in Atlanta by invitation at our expense. Write in detail to Orkin Exterminating Co., Inc., 713 W. Peachtree St., Atlanta, Ga. Attention: Personnel Dept.

WANTED: MANAGERS for branch offices. Rapidly expanding pest control firm requires high-type men to manage offices. Must have initiative, sales ability, and forcefulness. Prefer graduate entomologists with practical experience. Will also consider applications from men now in the pest control field, who possess good education, sound technical, and business background. Excellent opportunity to become associated with progressive organization enjoying solid financial position. Salary and percentage. Submit complete data: age, education, experience, and other pertinent details, together with photo. All replies strictly confidential. L. L. Crosby, President, Commonwealth Sanitation Co., 3567 Bigelow Blvd., Pittsburgh 13, Pa.

TECHNICAL DIRECTOR—We have a very important position for an outstanding man, with entomological and chemical background and a record of successful accomplishment, to head service department of rapidly expanding pest control firm with home offices in Pittsburgh. This is an important position for a man with experience and possessing managerial ability plus. Remuneration to meet full expectations plus opportunity for profit-sharing interest. This is an unusual opportunity for the right man. All replies strictly confidential. Submit account of academic and professional training, past affiliations, earnings, photo and any other pertinent facts to: L. L. Crosby, President, Commonwealth Sanitation Co., 3567 Bigelow Blvd., Pittsburgh 13, Pa.

TECHNICAL PERSONNEL wanted by large service-minded company. Duties to assist branch offices in pest and termite control services. Some travel and no sales required. Degree helpful but not essential. Benefits include life insurance, hospitalization, pension, paid vacation, and sick leave. Ample opportunity for advancement. Send resume including salary history. All replies confidential. Interviews in Atlanta by invitation at our expense. Write in detail to Orkin Exterminating Co., Inc., 713 W. Peachtree St., Atlanta, Ga. Attention: Technical Dept.

FOR SALE

DYNA-FOG JR. insecticidal fogging machine used as a demonstrator only. Price $224.50. Hub States Chemical & Equipment Co., 1255 N. Windsor St., Indianapolis 1, Ind.

WANT TO BUY

WILL PAY TOP PRICE for exterminating business in New York City area. Cash. Replies confidential. Box 439, Pest Control magazine.

WILL BUY PEST CONTROL businesses. We are ready to buy several more pest control companies to add to the Commonwealth group. We prefer to retain existing management and personnel, under lucrative profit-sharing arrangements offering unusual potentialities for greatly enhancing present income. All negotiations completely confidential. Write William L. Yockey, Comptroller, Commonwealth Sanitation Co., 3567 Bigelow Blvd., Pittsburgh 13, Pa.

EXTERMINATING business N Y C or Long Island area. Replies confidential. Edward Kaplan, 80-11 165th St., Jamaica 32, N. Y. JA 6-8882.

WILL PAY TOP PRICE for exterminating business in New York City area. Cash. Replies confidential. Box 478, Pest Control magazine.

MISCELLANEOUS

$250,000 TO INVEST in pest control concerns in Ohio, Indiana, Kentucky, W. Virginia, Illinois. We will buy outright entire assets, or will buy routes. Wire or write to R. B. Hoover, Court and Elm Streets, Cincinnati 2, O. We also have available loans to going concerns at low rates.

— Advertisers —

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Fined in Sanitation Cases

A Lynn, Mass. food processing company was fined $100 recently for preparing bread and cookies, contaminated with rodent and insect filth, under insanitary conditions.

A $2,000 fine was levied against a Beaumont, Tex. rice mill for packing rice, contaminated with rodent filth, under insanitary conditions.

A food distributing company in Denver, Colo. was fined $1,400 and its president, $350, for storing flour and rice, which were contaminated with rodent filth, under insanitary conditions.

Every Serviceman

Should Have His Own

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THE MODERN KNEE PROTECTOR

An absolute necessity for termite operators and other servicemen whose work requires kneeling on the ground or floor. Protects clothes and skin.

√ **Form-fitting to stay exactly where they are placed**
√ **Reinforced extra strong, flexible rubber.** √ **Comfortable**
√ **Long-wearing durability. Another Centro Development!**

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PEST CONTROL

1900 Euclid Ave. **Cleveland 15, Ohio**

NOW you can picnic or eat outdoors without being troubled by pesky mosquitos, with NEW

Skeeter Scooter

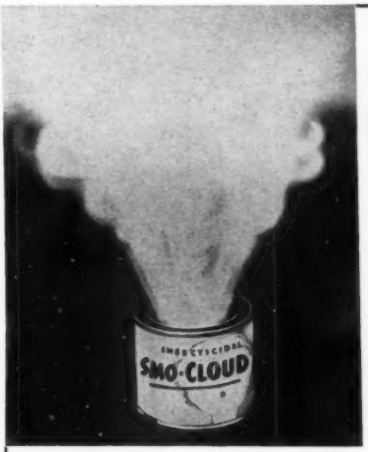
by **Riverdale**

Here is a new mosquito killer that works wonders. It kills mosquitos and lasts for days—even weeks. It is not harmful to humans, pets, plants or wild life, when used as directed. This new miracle killer is easy to handle—no messy greasy salve or lotion to apply—no aerosol mist that evaporates or disappears with the slightest breeze. New Skeeter Scooter is fine granules that you sow, like grass seed, over a given area for COMPLETE mosquito protection. It's so easy—yet so effective. Comes in 5 lb. bags—at $2.25—(1 lb. will adequately cover a small lawn—2 lbs. for a large lawn.)

LOOK—For the green and white label. Skeeter Scooter is made of Vermiculite and DDT.

Riverdale CHEMICAL COMPANY

CHICAGO HEIGHTS, ILLINOIS
PHONE: SKYLINE 6-2010



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Pestales

Up to Parr. We always realized the New England Pest Control Association was a distinguished group, but adding TV-stars to its membership is a new distinction! We're referring to the association's newest addition, "Tonight" funnyman Jack Paar. He was awarded an honorary membership a few weeks ago after he jokingly forecast a bedbug invasion of Boston this year. His remark, made during a regular telecast, set the association's Honorary Member Committee right to work. Committeemen Robert H. J. Pelletier, Ideal Spray Co., Lynnfield, Mass., George R. Elliot, Ransford Pest Control, Inc., Worcester, Mass., and Charles W. Houghton, Safety Fumigant Co., Boston, drafted a proclamation and sent it to emcee Parr, who read it on his popular variety show two nights later. Proclaimed the association: "Whereas, a latter day Paul Revere has alerted our community and craft that the bedbugs are coming, and; whereas, forewarned is forearmed, and; whereas, this humanitarian coup tolls certain doom for the abominable species Cimex lectularius in the Hub of the Universe, therefore, be it resolved that Jack Parr be acclaimed an Honorary Member of the New England Pest Control Association, Inc., and further, that he be invested with the special jewel of Master of the Mattress, with full privileges implied, excepting only such as are banned in Boston."

* * *

Bombs away! Socialite women in a Rome theater panicked a few weeks ago when live mice, strapped into tri-colored paper parachutes, wafted down upon them from a balcony during a performance. Police later arrested seven young toughs who admitted causing the disturbance. They were members of a neo-Fascist organization disturbed by passages in the play which attacked the late Benito Mussolini, one-time Fascist dictator in Italy. *But there appeared to be question among some women about who were the biggest pests — the mice which tumbled into their gowns or the men who came to their assistance.*

* * *

Arkansas PCO gagman. Releases from various pest control associations pour into our office daily, some loaded with wit. And among the wittiest are those from Arkansas PCA scribe, David Anderson, Evans Laboratories, Inc., Little Rock. That's why we would like to tip our hat to Anderson this month. From our latest Arkansas PCA Newsletter, a typical Andersonism: "All who will serve as area leaders under the Civil Defense set up, contact me at once. If you have a CD sticker on your car, you can get into the bombed out area for the choice looting. Might even get into Orkin's office and steal the formula for Orkil."

* * *

Buzzin' by the dozen. In the remote Lubang Island jungles of the Philippines a few weeks ago, a swarm of bees put to rout a search party that was hunting a pair of World War II Japanese hold-outs. The two soldiers have hidden out in the jungles for 14 years in the belief the war is still on. *Apparently what they lacked in snipers, they made up for in bees.*

* * *

Mrs. Breed Passes Away. The industry was saddened to learn of the death April 10 of Mrs. Margaret Breed, wife of Edmund N. Breed. As owners and operators of Peoria Pest Control Co., Peoria, Ill., Ed and the late Mrs. Breed were regulars at annual conventions of the National Pest Control Association.

* * *

Astronaut rejects. The Air Force has declined an offer by a Brawley, Calif. youngster who wanted to furnish 16 pet mice for space travel experiments. Nine-year-old Larry Heath wrote President Eisenhower that "my mother and daddy say I have to get rid of my mice because they are having too many babies." *Not an uncommon complaint heard by PCOs.*

A REFRESHING MINT FRAGRANCE FOR YOUR CHEMICAL SPECIALTIES

Here's a fine, long-lasting fragrance for your chemical specialty items. It efficiently masks the heavy odor of the chemical and, at the same time, adds a pleasant, sales appealing fragrance to your product. *Why not order a trial pound for your own tests!*

MINTALIA IS PERFECT FOR:

Liquid Soaps and Detergents—use ¼-½ oz. to 1 gallon
Air Deodorants—use 2-3 ozs. to 1 gallon (50% Alcohol)
Paradichlorobenzene—use ½ to 1%
Deodorizer Fluid—use 10 to 20%
Insecticides—use ⅛ to ¼ oz. to 1 gallon
Aerosols—use ¼ to ½ of 1%

PRICE: 1 pound $3.75 . . . 5 pounds $3.50

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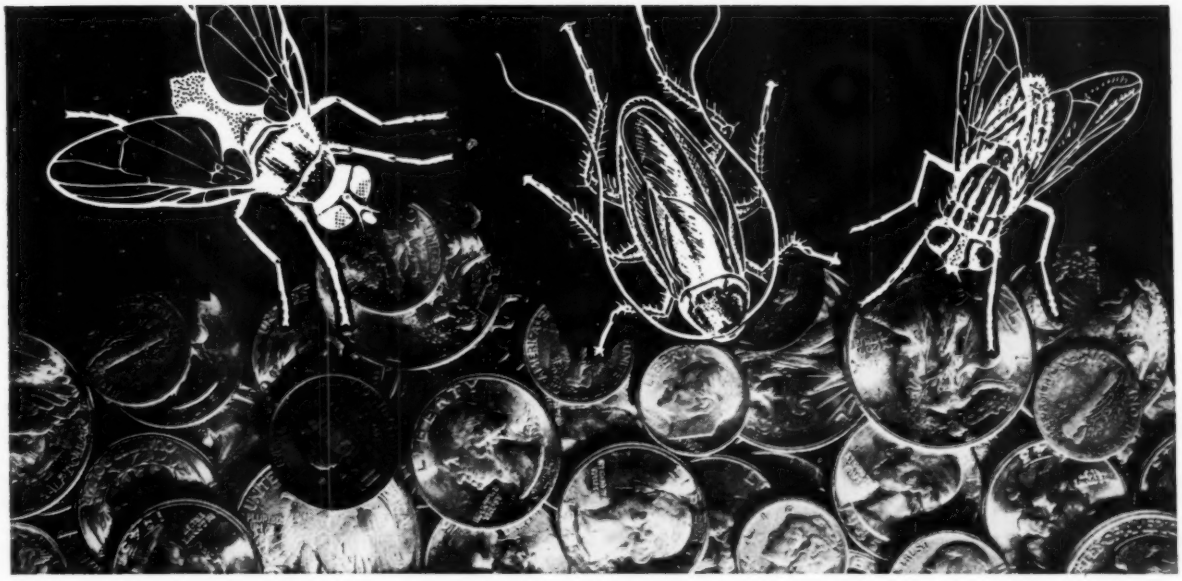
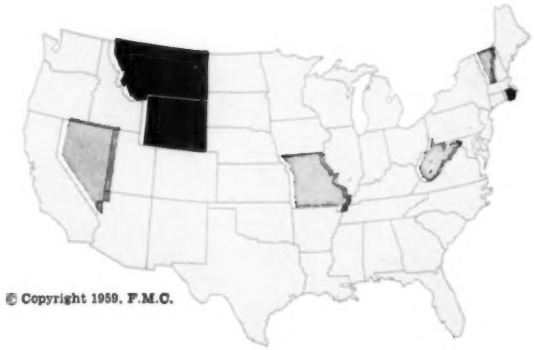


RESISTANT INSECTS EAT INTO SALES!

...don't blame your salesmen, the RESISTANT INSECT may be the culprit !



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FAIRFIELD CHEMICALS' First National Insect Resistance Survey
RESISTANT INSECT DISTRIBUTION

Insect Resistance | No Insect Resistance | States Unreported

(†) *Survey available upon request on your company letterhead.*
(*) *Reg. U. S. Pat. Off. FMC*

In a recent nationwide survey† leading Entomologists reported flies and roaches have "learned-to-live" with many widely used insecticides. Once powerful formulations no longer prove fully effective. Worse, each new insect generation becomes more and more immune.

If your insecticide sales have slumped, blame the resistant insect! It's time to take 'him' seriously. The survey showed that formulations with PYRENONE* offered long range effectiveness and high killing power, are non-toxic to humans and warm blood animals. Pyrenone, a combination of pyrethrins and piperonyl butoxide, proved to be the safest, surest, most economical insecticide base. It's time to put performance... *and profits, naturally*... back into your insecticides. Reformulate with Pyrenone.

KEEP YOUR INSECTICIDES MARKETABLE

- Periodically check insect resistance to your products.
- Tailor your formulations to meet specific needs.
- Prescribe proper application methods.
- Reformulate to include Pyrenone.

Let your Fairfield representative help solve your insecticide sales problem. Contact him today!

Pyrenone*

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Dieldrin is long-lasting. It maintains its residual potency for many years after application. Even in soil where lime, cement and other alkaline materials are present dieldrin keeps up effective, long-lasting control. Dieldrin is easily applied with conventional equipment.

Issue your guarantee with confidence . . . use dieldrin in all of your termite control operations. You'll build bigger sales and greater customer satisfaction. For latest technical information on dieldrin, write to:

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